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GENERIC PAYLOAD SIMULATOR REQUIREMENTS DOCUMENT,
VOLUME I

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ABSTRACT

This Generic Payload Simulator Requirements Document (PSRD), Volume I, provides the requirements for a Payload Training Unit (PTU). This document includes the specific functional and interface requirements for the hardware mockups and software elements that will comprise a PTU. The PTU will be developed by the Payload Developer (PD) and integrated into the Johnson Space Center (JSC) Space Station Training Facility (SSTF)/Payload Training Capability (PTC) and/or the Space Vehicle Mockup Facility (SVMF) and Neutral Buoyancy Lab (NBL). An experiment-specific PSRD, Volume II, to be published at Increment minus (I-)18, will provide a list of PD-provided components, SSTF/PTC-provided components, and a list of Laboratory Support Equipment (LSE)/Station Support Equipment (SSE) requirements; unique 1-g support requirements; PTU configuration/layout diagram; Payload Resource Utilization (PRU) data; Instructor/Operator Station (IOS) display requirements, malfunction descriptions and flags, and Input/Output (I/O) data maps.

This document, SSP 58026-01, supersedes the Generic Payload Simulator Requirements Document, Volume I, SSP 50411-01, dated September 1, 1998.

KEY WORDS

Payload Training Capability

Payload Training Unit

Requirements

Simulator

Space Station Mockup and Trainer Facility

Space Station Training Facility

Training

Training Objective

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SECTION 1, INTRODUCTION

This document is the Generic PSRD for any payload that will be operated on board the International Space Station (ISS) that requires a training unit to be delivered to a JSC training facility. The requirements in this document define a PTU that will reside at the SSTF/PTC, NBL, and/or SVMF to support training for the Space Station and/or Shuttle crew, the Payload Operations Integration Center (POIC) cadre, the Mission Control Center – Houston (MCC-H) flight controllers, and the PD teams. The requirements provided in this document shall apply to the PDs for all U.S. payloads or payloads that will reside in the U.S. module, unless specifically waived by the Training Strategy Team (TST) for that payload. An experiment-specific PSRD, Volume II, to be published at I-18 will provide a list of PD-provided components, SSTF/PTC-provided components, and a list of LSE/SSE requirements; unique 1-g support requirements; PTU configuration/layout diagram; PRU data; IOS display requirements, malfunction descriptions and flags, and I/O data maps.

The following organizations are involved in defining and reviewing the simulator requirements and design, in integrating and testing the simulator in the SSTF/PTC, and in operating the simulator for training. The abbreviations provided here will be used throughout this PSRD to indicate these organizations:

A. PD – Payload Developer of the individual payload (experiment) for which the PTU is defined.

B. PTI – NASA MSFC Payload Training Integrator responsible for developing the training plans and schedules for the integrated complement of payloads.

C. SE – Simulation Engineer from the MSFC Payload Operations Integration Function contractor that provides simulator and training support for payloads.

D. DT – NASA JSC Space Flight Training Division personnel that provide crew training support for ISS systems, and for payloads after the first flight.

E. DK – NASA JSC Simulator Operations and Technology Division personnel that are responsible for the administration, integration, and operation of the SSTF/PTC.

Specifications of the SSTF/PTC and its interfaces to PTUs are contained in the Payload User Development Guide (PUDG), SSP 50323, current version. In addition, security, safety, and logistics requirements for PTUs are also contained in the current issue of the PUDG. SVMF procedures for receiving, inspection, handling, movement, and shipment of PTUs are addressed in the current issue of the Standard Operating Procedures for Customer Supplied Products, SP52-WI-0042. This PSRD, in conjunction with the PUDG and SVMF and NBL procedures, shall provide the PD with the requirements and information to build a PTU to be integrated into and interface with the SSTF/PTC and/or SVMF. An SE shall be assigned to each payload to coordinate the development of the PTU with the PD and the delivery and integration of the PTU with the SSTF/PTC and/or SVMF.

The SSTF/PTC's classification system for integrated PTUs in the SSTF/PTC is described in Section B.1 of Appendix B. All integrated PTUs shall be of Class IIb (Self-contained Software Simulation – with Hardware Panels/Interfaces, if appropriate), unless special arrangements are made through the TST. The classification system used for hardware training units for the SVMF are detailed in Section B.2 of Appendix B. Appendix B also describes the PTU component fidelity specifications that will be used in this PSRD. These fidelity specifications are intended to provide a logical and consistent description of the necessary level of fidelity that a PTU component requires to support the training task for which it is intended.

1.1 PURPOSE

The purpose of the PSRD is to define the functional and interface requirements for the PTU necessary to support PTC training for an integrated rack payload. This document identifies the basic training objectives that will be supported by the PTU; the approach used to develop the PTU; the parties responsible for providing the PTU hardware and software components; and (in conjunction with the PUDG) the parties responsible for integrating, verifying, operating, and maintaining the PTU. The PD is expected to respond to these requirements with a PTU Trainer Development Specification (TDS) for review and comment as part of the Preliminary Design Review (PDR) and Critical Design Review (CDR) for the payload flight unit. The PTU developed from these requirements will be used at JSC training facilities to conduct both individual payload training and payload complement training, as well as support simulations involving the Station crew, MCC-H ground controllers, POIC cadre, and PD teams.

A payload-specific PSRD, Volume II, to be developed at I-18 months by MSFC will provide a list of PD-provided components, SSTF/PTC-provided components, and a list of LSE/SSE requirements; unique 1-g support requirements; PTU configuration/layout diagram; PRU data; IOS display requirements, malfunction descriptions and flags, and I/O data maps.

1.2 SCOPE

This PSRD, Volume I, is intended to provide the requirements for a PTU of any payload that will be provided for use in JSC training facilities.

This PSRD is divided into six major sections and eight appendices.

A. Section 1, "Introduction," provides the purpose and scope of this document.

B. Section 2, "Applicable Documents," lists the documents that were referenced in the development of this PSRD.

C. Section 3, “PTU Overview,” describes the training objectives and training utilization that the PTU will support and provides the top-level requirements for the integrated PTU.

D. Section 4, “PTU Software Requirements,” specifies the software capabilities required for the PTU to provide training within the SSTF/PTC simulation environment.

E. Section 5, “PTU Mockup Hardware Requirements,” specifies the requirements for the PTU hardware mockups including the rack-mounted components, stowage, and interface hardware.

F. Section 6, “PTU Development and Verification Process,” describes the development and verification process that is used in creating the PTU.

G. Appendix A lists the abbreviations and acronyms used in this document.

H. Appendix B provides the definition of the simulator class levels.

I. Appendix C provides detailed requirements specific to Integrated Rack PTUs.

J. Appendix D provides detailed requirements specific to EXPRESS Sub-rack PTUs.

K. Appendix E provides detailed requirements specific to Stand-alone PTUs.

L. Appendix F provides detailed requirements specific to EXPRESS Pallet PTU.

M. Appendix G provides detailed requirements specific to EXPRESS Pallet Payload PTUs.

N. Appendix H provides detailed requirements specific to Attached Payload PTUs.

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SECTION 2, DOCUMENTS

2.1 APPLICABLE DOCUMENTS

The following references may include documents, specifications, standards, guidelines, procedures, handbooks, and other special publications. These documents, of the exact issue shown, form a part of these requirements to the extent specified herein. Unless the exact issue and date are identified, the “Current Issue” cited in the contract Applicable Documents List applies. Inclusion of applicable documents herein does not in any way supersede the contractual order of preference.

None

A. NASA – MSFC Documents

SSP 52000-IDD-ERP	ISS EXPRESS Rack Payloads Interface Definition Document (IDD)
SSP 58309	Payload Training Implementation Plan (PTIP)

B. NASA – JSC Documents

SSP 50323	Payload User Development Guide (PUDG) for the Space Station Training Facility/Payload Training Capability
JSC 26452	Mockup and Integration Laboratory Users Manual
JSC 26995	Neutral Buoyancy Laboratory Guidelines
JSC 36307	NASA Training Implementation Plan (NTIP)

C. Boeing Documents

No Number	EXPRESS 8/2 Rack Simulator Interface IDD
No Number	EXPRESS Pallet Simulator IDD

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SECTION 3, PTU OVERVIEW

The PTUs that shall be developed for JSC training facilities are intended to provide training for the crew, as well as an opportunity to receive flight-like feedback; recognize visual nomenclature and graphics; realize reach constraints; and manipulate parts stowage, all while operating within the constraints of the ISS module in which they reside or other appropriate environment (with the possible exception of Stand-alone PTUs, see Appendix E). Integrated PTUs shall also support training of Ground Support Personnel (GSP). The PTU shall be designed such that training sessions can include both nominal and off-nominal operation scenarios.

3.1 TRAINING OBJECTIVES

The Training Objectives which the PTU shall support are listed in Table 3-I, along with the element of the PTU that shall provide the training capability. Note that this is a comprehensive list; all training objectives on this list are not applicable to all payloads. The planned flight operations for the payload, in particular those operations involving the crew or ground commanding and monitoring, shall be the criteria used to determine the applicability of the training objectives.

3.2 PTU UTILIZATION

The PTU (or PTUs) shall be capable of supporting training in the following nine categories: Payload Science/Operations, Payload Transport, Payload Transfer, Payload Proficiency, Payload Refresher, Payload Complement, Payload-Only Simulation, Integrated Payload-Only Simulations, and Joint Multi-Segment. Note that Transport and Transfer categories may not be applicable to all payloads, and the need for this training will be determined by the PD. The first five training types involve the individual payload; the next two involve the entire payload complement for the increment; and the last two involve the payload complement integrated with the ground support elements. These training categories are fully defined in the Payload Training Implementation Plan (PTIP).

3.3 PTU USER'S GUIDE

The PD shall deliver a PTU User's Guide with the PTU. This Guide shall include, as a minimum, the following information:

A. Hardware and Software Documentation shall be provided for any components of the PTUs that need to be handled, configured, connected, modified, or maintained by MSFC or DK personnel.

TABLE 3-I TRAINING OBJECTIVES (Sheet 1 of 2)

TRAINING OBJECTIVE	PTU ELEMENT/CAPABILITY
Payload Familiarization • Equipment Overview • Operations Overview	PTU shall be used to provide a payload overview to crew.
De-installation → Transfer → Installation • Disconnect/De-Install from Transport Location • Transfer Payload to ISS • Install/Connect to Operating Location • Provide Support Systems Interfaces - Power - Data (1553 Bus, PEHG LAN) - Water Cooling Loops (Low and Medium Temperature) - Waste Gas - Vacuum - Nitrogen Gas	Generic Rack Transfer training equipment will be provided, the PTU need not support those training objectives. PTU hardware mockups and/or software simulation shall support any payload-specific transfer training objective, e.g., those involving special connections, non-generic installation steps, or special checkout procedures.
Transport Operations • Status Monitoring • Caring for Animals or Plants	PTU hardware mockups and/or software simulation shall support the training for any activities performed during ascent or descent.
Nominal Operations • Payload Activation • Experiment Initiation or Modification • Status Monitoring - Filter Cleanings, etc. - Monitoring of Status - Feeding/Watering of Animals/Plants • Cartridge or Equipment Handling - Special Tools - Stowage - Special Sample Handling - Sample Preservation • Monitoring & Commanding via Laptop (or PCS) - Data Monitoring - Adjust Experiment Parameters - Data/Video Downlinking • Video/Photography • Oxygen Deficient Environment	PTU hardware mockups and/or software simulation shall support the training for all activities performed by the crew. Hardware mockups shall include components internal to the payload, if accessible to the crew, and all stowage components handled by the crew. Software simulation shall include all commands available to the crew and all data or signal available to the crew.

TABLE 3-I TRAINING OBJECTIVES (Sheet 2 of 2)

TRAINING OBJECTIVE	PTU ELEMENT/CAPABILITY
Malfunction Operations • Power • Temperatures • Communications • Water Loop • Fire and Smoke Detection	Malfunctions shall be simulated by the PTU if they involve crew safety or hazards, require rapid response to protect payload equipment or samples, or affect other elements of the ISS.
Ground Command and Telemetry • Monitoring of Data or Video Downlinks • Ground Commanding	PTU shall support interfaces (as applicable) to 1553 bus, PEHG LAN, and/or video link.
Safety/Hazard Management (to include only those crew safety issues that require special training) • Samples/Materials • Crew Interfaces • Operating Conditions (temp, pressure, etc.)	PTU shall provide hardware mockup and/or software simulation of all safety/hazard issues.
Special Maintenance (Hands-On) • ORU Replacement • On-Orbit Maintenance (OOM)	Hardware mockup shall include all crew interfaces, access envelopes, and flight-like mounting and connection hardware.

B. Installation Instructions shall be provided which include physical installation, internal interconnections, loading of software, and any other processes that are required to install or setup the PTU in preparation for training.

C. Miscellaneous Handling Instructions shall be provided if the PTU requires any special handling.

D. Checkout Procedures shall be provided to perform a verification of the PTU health. Note that this does not need to include a detailed verification of PTU functionality; its purpose is to verify that the PTU is operational after installation or modification.

E. Initialization Instructions shall be provided to power up the PTU and configure it for a training session.

F. Maintenance Procedures shall be provided for those routine maintenance operations that DK personnel are expected to perform.

G. Emergency Shutdown Procedures shall be provided if these are necessary. No procedures are required if the PTU can be shut down by simply removing power.

H. A report of the safety hazards associated with any component of the PTU.

I. A report of any operational precautions associated with the PTU.

J. PTU Operating Procedures.

3.4 FACILITY CLASS PTU TO SUB-CLASS PAYLOAD PTU IDD

Multi-use Facility Class PDs (e.g., EXPRESS Rack) are required to produce an IDD to define the interface between the Facility Class PTU and any payload PTUs that mount within that facility PTU and have an interface to facility resources such as power, command and data, water, gas, vacuum, etc. This IDD shall include an extension of the SSTF/PTC Payload Simulation Network (PsimNet) interface to the Sub-class PTU. Further details are provided in Appendices C and F for particular facility class PTUs. This document will be controlled at the facility level and be provided by the PD to those PDs that are responsible for the development of individual Sub-class PTUs.

3.5 PTU LOGISTICS

The PD shall be responsible for verifying that the PD-provided PTU components are in good working order and meet the requirements specified in this PSRD before shipping. The PD shall be responsible for shipping the components as specified in Section 3.1.5 of the PUDG. The PD shall provide MSFC and DK personnel notice of, and negotiate, any deviation from the logistics and handling procedures specified in Appendix I, Section 10.5 of the PUDG. The configuration and installation of the PTU components shall be as detailed in Section 3.1.7 of the PUDG. Any payload-specific installation instructions shall be provided in the PTU User’s Guide.

Maintenance, sustaining engineering, and post-training support of the PTU shall be the responsibility of the PD as detailed in Sections 3.1.8 through 3.1.10 of the PUDG. Any routine or specific maintenance requirements for the PTU to be performed by DK personnel shall be negotiated between the PD and DK, and maintenance procedures shall be provided in the PTU User’s Guide. Once the training requirements for the PTU have been fulfilled, packing and shipping of the simulator shall be performed by the PD or MSFC as detailed in Sections 3.1.11 and 3.1.12 of the PUDG.

SECTION 4, PTU SOFTWARE REQUIREMENTS

This section specifies the software capabilities required for a PTU to operate within the simulation environment for each JSC training facility.

4.1 PTU SOFTWARE FOR THE SSTF/PTC

A PTU for the SSTF/PTC is identified in the PUDG as a PTS (Payload Training Simulator). This PTU shall have PD-provided software that simulates all major aspects of the flight payload processor, and also provides simulation-unique functions. The PTU software shall reside in a PD-provided processor, or in a Payload Simulator Environment (PSE), and shall provide a flight-like representation of the operations and interfaces of the payload. The software shall provide flight-like interfaces to the crew and ground controllers by responding to commands and providing monitoring data through the 1553 bus, the Payload Ethernet Hub Gateway (PEHG) Local Area Network (LAN), the video link, and directly to the payload's front panels (with the exception of a Stand-alone PTU, see Appendix E). The PTU shall respond to Stationwide events (failure coolant loop, Fire Detection System (FDS) event, etc.) that would impact operations of the payload as detailed in the PUDG.

Any software targeted for a processor internal to the PTU shall be provided by the PD. The PD shall also provide a copy of any software intended for a payload-specific laptop or any payload-specific software intended for use on a Station PCS.

4.1.1 PsimNet Message Interface

The PTU software shall interface with the SSTF/PTC simulation system through the PsimNet to perform initialization, mode control, and malfunction insertion. The interface specifications for the PsimNet communications are provided in Appendix III, Section 30.4, of the PUDG. The following are specific types of messages discussed in the PUDG that shall be supported by the PTU software:

A. Simulation control messages

B. Station data messages

C. PTU data messages

D. Malfunction messages

E. Poke messages

F. Panel switch override and panel switch verification messages

G. Error messages

The following messages shall apply to Facility Class PTUs only (Integrated Racks, EXPRESS Pallet, Attached Payloads, etc.) as specified in Appendices C, F, and H.

A. Establish connection messages

B. Ping messages

4.1.2 Operating Modes

The PTU shall be capable of receiving mode control messages from the IOS via the PsimNet. The formats for these messages are specified in the Appendix III, Section 30.4.2.3, of the PUDG. The PTU software shall respond to messages to operate in the following different modes: Freeze, Initialize, Datastore, Run, Hold, and Terminate. The inter-relationship of these modes and specific requirements for the PTU software in these modes are detailed in Section 30.3.3.5.2 of the PUDG.

4.1.3 Simulation of Nominal Operations

The PTU software shall provide simulation of the nominal operations of the payload that involve crew interactions, either through hardware elements or through software displays. Operations that shall be simulated include, but are not limited to, activation/deactivation, hardware setup, calibration, sample changeout, science gathering, and data and video management. The PTU shall also support ground control and monitoring of the crew's operations (with the exception of a Stand-alone PTU, see Appendix E). The PTU software shall also respond to changes in ISS resources (from the core systems models) by exhibiting the appropriate response in the payload's status (with the exception of a Stand-alone PTU, see Appendix E). The PTU shall also accept commands and provide housekeeping data for GSP training during joint training sessions involving the MCC-H, POIC, Telescience Support Centers (TSC), and/or User Operations Facility (UOF) sites unless waived by the TST.

4.1.4 Simulation of Malfunctions

The PTU software shall provide simulation of malfunctions that involve crew safety or hazards, require rapid response to protect payload equipment or samples, or affect elements of the ISS external to the payload. Malfunctions involving broken hardware shall either be provided via software simulation of the malfunction's effect, or, if more appropriate, via a broken component that can be substituted for the unbroken component in the PTU. The PTU software shall also respond to malfunctions or changes in ISS resources (from the core systems models) by exhibiting the appropriate response in the payload's status (with the exception of a Stand-alone PTU, see Appendix E).

4.2 PTU SOFTWARE FOR THE SVMF

The SVMF does not support integrated software simulations of the type required in the SSTF/PTC. Those payload-specific ISS crew operations that require use of either the ISS or Shuttle remote manipulator arms (e.g., attached payload transfer, pallet payload installation, etc.) require the development of payload-specific software models for robotics training in the Multiuse Remote Manipulator Development Facility (MRMDF), and the Robotics Prototype Part Task Trainer (P2T2). DT personnel at JSC shall develop these models. The PD is responsible for the timely provision of data in support of the development of these software models. Typical data includes hardware dimensions, mass properties, attachment hardware locations and types, grapple fixture locations and type, etc. Refer to the NASA NTIP for more information on JSC robotics facilities.

4.3 PTU SOFTWARE FOR THE NBL

The NBL does not support software simulations of the type required in the SSTF/PTC.

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SECTION 5, PTU MOCKUP HARDWARE REQUIREMENTS

This section identifies the PTU mockup hardware components required to support training activities. The PTU and its components, as well as their operational interfaces with the crew, and their physical interfaces with the ISS module mockups, if any, will be discussed in the following sections.

5.1 MOCKUP HARDWARE FOR SSTF/PTC

The rack provided with an integrated, Facility Class PTU shall support the installation of any appropriate sub-rack payloads. Mechanical supports for mounting sub-rack payloads, such as drawer guides, front panel rack mounting, or rear mounting, as appropriate, shall be provided by the PTU rack. Resources for the sub-rack payloads, including electrical power distribution and switching, command and data interfaces, and cooling air distribution, shall also be provided by the Facility Class PTU rack. Note that software interface requirements for sub-rack payloads are discussed in Section 4.

The front panel mockups specific to the PTU shall provide a functional fidelity training environment for the crew in which all Light Emitting Diodes (LED), switches, dials, displays, etc., operate in a flight-like manner. These components shall be interfaced to the PTU simulation software to provide the desired crew interactions. The physical mockups specific to the PTU shall provide a physical fidelity training environment for the crew in which all openings, volumes, doors, latches, etc., represent a flight-like environment.

5.2 SSMTF TRAINING HARDWARE COMPONENTS

5.2.1 Rack Rotation and Rack Pullout Hardware

Those payload-specific operations that require rotation of a payload rack (e.g., Orbital Replacement Unit (ORU) replacement, Active Rack Isolation System (ARIS) H/W installation, etc.) or the extension of pullouts that would cause an SSTF-provided International Standard Payload Rack (ISPR) to become overbalanced, cannot be supported in the SSTF/PTC. In order to provide crew training in these operations, a trainer shall be constructed by the PD for delivery to and use in the SVMF. The hardware trainer shall include all non-payload, on-orbit accessible internal rack ORUs with proper flight-like dimensions and attachment points for structural interfaces and substructure (cabling, fluid lines, etc.). Details of each hardware trainer design (if required by the TST) shall be included in the PD-provided TDS which defines the detailed specifications for each trainer/simulator to be supplied. This document shall be included in the PD's PDR and CDR data packages. The required contents of the trainer specifications document can be found in the NASA Payload Training Implementation Plan (NPTIP).

Additionally, some payload rack PTUs may require actual supplies of water, N2, power and/or vacuum in order to train critical, experiment-unique, payload operations. These resources are available to PTUs in the SVMF lab module mockup but not in the SSTF/PTC. Note that the SVMF lab module mockup does not support command and data capabilities, so it may be necessary to produce two trainers in order to support all ISS crew and GSP operations training. The need for a functional PTU resident in SVMF module mockups and/or the SSTF/PTC shall be determined by the TST process. If such an SVMF PTU is determined to be necessary, the PD shall be responsible for its design, production, and delivery. Details of the hardware trainer design (if required) shall be included in the PD-provided Prime Item Development Specification (PIDS) at PDR and CDR.

An “rotation-capable” ISPR meant for use in the SVMF requires the incorporation of a rack rotation assembly into the hardware trainer design. The rack rotation assembly shall be capable of rotating and maintaining a maximum extension of 80 degrees when the ISPR is fully populated and configured with all the ORU components. The rack rotation assembly shall be constructed such that rotation can be initiated by hand, and upon release of the rack at any angle, rotation shall stop. The rack rotation assembly shall interface with the SVMF lab module mockup as specified in interface drawing SK683-TBD. The rack rotation assembly shall have a 2.0 structural factor of safety.

5.2.2 Robotics Training Hardware

Those payload-specific operations that require use of either the ISS or Shuttle remote manipulator arms (e.g., attached payload transfer, pallet payload installation, etc.) may require the development of payload-specific hardware for robotics training in the MRMDF as determined by the TST process. This hardware consists of a volumetrically representative, light-weight model (balloon). DT will write the requirements for the balloons used with the MRMDF. Payloads which fall within the standard volume envelope may not be required to produce a balloon model.

5.3 NBL TRAINING HARDWARE COMPONENTS

Those payload-specific operations that require crew Extra-Vehicular Activity (EVA) may require the development of payload-specific hardware for EVA training in the NBL located at JSC as determined by the TST. The PD is responsible for the production and delivery of this mockup hardware to the NBL in coordination with Mission Operations Directorate (MOD) personnel as specified in the NTIP and the NBL Guide.

5.4 STOWAGE

The PTU shall include all stowage items associated with the payload, whether stowed internally to the PTU rack or in other locations. The PTU shall also include all stowage containers associated with the rack, along with the associated foam or other support material. Stowage containers associated with other racks shall be provided by their respective PD.

5.5 SUPPORT EQUIPMENT

The PTU shall include all payload-unique support items required to operate the trainer in a flight-like manner as deemed necessary by the TST. These items will be included in the inventory of PTU components delivered to the appropriate JSC training facility.

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SECTION 6, PTU DEVELOPMENT AND VERIFICATION PROCESS

The PTU development and verification process is briefly described in this section. The process is defined in detail in the NASA PTIP, SSP 58309, latest version. The PD shall support the process for development and verification of the specific type of PTU to be used at the SSTF/PTC for payload training. The process is slightly modified for each type of PTU as specified in the PTIP and the payload-specific PSRD appendices in this document.

6.1 PTU DEVELOPMENT

The PD shall develop the PTU based on the operational and interface requirements specified in this PSRD, Volume I, and, by reference, in the PUDG. As part of the development process, the PD shall provide, within the payload’s PDR data package, a “ridable” TDS for the PTU, which will contain detailed information on the PTU’s capabilities. For Facility Class payloads, the development of the PTU interfaces to the SSTF/PTC host computer shall be accomplished using a Simulator Test Fixture (STFx) included as part of the PSE and a Suitcase Test Environment for Payloads (STEP). The STFx provides a simulation of the SSTF host computer IOS command and data functions. The STEP provides a simulation of the 1553B bus and the payload Ethernet.

For integrated EXPRESS Sub-rack payloads, the development of the PTU interfaces to the EXPRESS Rack PTU shall be accomplished using a GFE Suitcase Simulator for EXPPESS (ScS-E). The ScS-E provides a simulation of the command and data interfaces to the EXPRESS Rack Interface Controller (RIC).

For integrated EXPRESS Pallet payloads, the development of the PTU interfaces to the EXPRESS Pallet PTU shall be accomplished using a Suitcase Simulator for EXPPESS Pallet (ScS-EP). The ScS-EP provides a simulation of the command and data interfaces to the EXPRESS Pallet Interface Controller.

Prior to delivering the PTU to the appropriate JSC training facility, the PD shall host an MSFC representative to conduct a Simulator Pre-Shipment Test. The purpose of this test shall be to ensure that the PTU meets the operational and interface requirements contained in the PSRD/PUDG/TDS. The test shall be conducted using the applicable portions of the Payload Simulator Test Procedures (PSTP), developed by MSFC. Problems encountered during the Simulator Pre-Shipment Test shall be corrected by the PD prior to shipping the PTU to the SSTF/PTC.

The PD shall be responsible for crating and shipping to the appropriate JSC training facility the PTU components as specified in the PUDG and other appropriate documents. Those components of the PTU which are considered “hand-carried” (e.g., those non-integrated components that have other uses or that are expendable), shall be delivered to the

SSTF/PTC at least 24 hours prior to the training sessions. The configuration and installation of the PTU components shall be compliant with the PUDG. Any payload-specific installation instructions will be included in the PTU User's Guide.

6.2 PAYLOAD SIMULATOR INVENTORY AND INTERFACE CHECKOUT (PSIIC)

A PSIIC shall be performed at the SSTF/PTC, SVMF, or NBL soon after the PTU is received. For a PTU that shall be integrated in the SSTF/PTC, the PSIIC shall occur in two phases. Only phase one of the PSIIC will be applicable for a Stand-Alone Trainer (SAT).

The objectives of phase one of the PSIIC are to verify that all PTU components expected were received and that no damage occurred to the PTU during shipment. In phase one, the inventory list and checkout procedures in the PSTP are used for a limited checkout of the PTU. The test shall be performed by MSFC and the PD, with participation required by DK and suggested participation by the DT instructors.

In phase two of the PSIIC, a further checkout of the integration and operations of the simulator is required. The objectives of phase two are to verify that all PTU components' interface requirements have been met and to test those interfaces prior to installation and interface with the SSTF/PTC systems. An Integrated Rack PTU shall be connected to a GFE STFx and a STEP, and a test procedure written by DK shall be run. Phase two of the PSIIC shall be performed by DK, with participation required by SE and PD. Similarly an EXPRESS Rack payload will be connected to a STEP-E, and a pallet payload will be connected to a ScS-EP.

6.3 PAYLOAD SIMULATOR ACCEPTANCE TEST (PSAT)

A PSAT will be performed for all integrated PTUs. The objective of the PSAT is to verify that the PTU, once integrated with the SSTF/PTC systems, meets the requirements defined in the TDS and the PSRD, Volume II. The PSAT will be performed using the PSTP written by MSFC. The SE will chair the PSAT, which will be performed by MSFC with support from the PD and DK personnel. Stand-alone PTUs are not required to undergo a PSAT.

6.4 PAYLOAD TRAINING DRY RUN (PTDR)

A PTDR shall be performed to verify that the PTU and all support materials are ready for use in training. This event shall be chaired by the SE, with required attendance of MSFC, DT instructors, and a crew representative. DK personnel or their assigned representative are required to support this event, and the PD must attend if the instructor is PD provided. This event, using the Payload Training Lesson Plan (PTLP) and crew procedures, is a dry run of the payload crew classroom and hands-on training sessions and must be completed successfully prior to crew training at the SSTF/PTC.

6.5 PAYLOAD COMPLEMENT REQUIREMENTS TEST (PCRT)

Similar tests will performed for trainer units provided to the SVMF.

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APPENDIX A

ABBREVIATIONS AND ACRONYMS

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A, ABBREVIATIONS AND ACRONYMS

A	Ampere
ac	Alternating Current
AOS	Acquisition Of Signal
ARIS	Active Rack Isolation System
Btu	British Thermal Unit
C&DH	Command and Data Handling System
C&T	Communications and Tracking
CDR	Critical Design Review
COTS	Commercial Off-The-Shelf
CRT	Cathode Ray Tube
DK	NASA JSC Simulator Operations and Technology Division
DRR	Document Release Record
DT	NASA JSC Space Flight Training Division
E	Envelope Fidelity
ECLSS	Environmental Control and Life Support System
EPS	Electrical Power System
EVA	Extra-Vehicular Activity
EXPCA	EXPRESS Pallet Controller Assembly
EXPRESS	EXpedite the PRocessing of Experiments to Space Station
F	Functional Fidelity
FDS	Fire Detection System
FEU	Flight Equivalent Unit
FSW	Flight Software
GFE	Government-Furnished Equipment
GN&C	Guidance, Navigation, and Control
GSP	Ground Support Personnel
H/W	Hardware
HRDL	High-Rate Data Link
Hz	Hertz
I-	Increment minus
IDD	Interface Definition Document
IIP	ISPR-mounted Interface Panel

IOS	Instructor/Operator Station
ISPR	International Standard Payload Rack
ISS	International Space Station
JSC	Johnson Space Center
kW	Kilowatt
LAN	Local Area Network
LED	Light Emitting Diode
LNS	Lab Nitrogen System
LOS	Loss Of Signal
LSE	Laboratory Support Equipment
MCC-H	Mission Control Center - Houston
MDL	Middeck Locker
MDM	Multiplexer/Demultiplexer
MOD	Mission Operations Directorate
MRMDF	Multi-use Remote Manipulator Development Facility
MSFC	Marshall Space Flight Center
NBL	Neutral Buoyancy Laboratory
NPTIP	NASA Payload Training Implementation Plan
NTIP	NASA Training Implementation Plan
OBCS	On-Board Computer System
OOM	On-Orbit Maintenance
ORU	Orbital Replacement Unit
P	Physical Fidelity
P2T2	Robotics Prototype Part Task Trainer
PAS	Payload Application Software
PCRC	Payload Complement Requirements Checklist
PCRT	Payload Complement Requirements Test
PCS	Portable Computer System
PD	Payload Developer
PDC	Payload Development Center
PDL	Payload Data Library
PDR	Preliminary Design Review
PEHB	Payload Ethernet Hub Bridge
PEHG	Payload Ethernet Hub Gateway
PEP	Payload Executive Processor

PES	Payload Executive Software
PIDS	Prime Item Development Specification
POIC	Payload Operations Integration Center
PRU	Payload Resource Utilization
PSAT	Payload Simulator Acceptance Test
PSE	Payload Simulator Environment
psi	Pounds per Square Inch
PSIIC	Payload Simulator Inventory and Interface Checkout
PSimNet	Payload Simulation Network
PSRD	Payload Simulator Requirements Document
PSTP	Payload Simulator Test Procedure
PTC	Payload Training Capability
PTI	Payload Training Integrator
PTIP	Payload Training Implementation Plan
PTLP	Payload Training Lesson Plan
PTDR	Payload Training Dry Run
PTS	Payload Training Simulator
PTU	Payload Training Unit
PUDG	Payload User Development Guide (for the SSTF/PTC)
RIC	Rack Interface Controller
RT	Remote Terminal
S/W	Software
SAT	Stand-Alone Trainer
SCE	Signal Conversion Equipment
ScS-E	Suitcase Simulator for EXPRESS
ScS-EP	Suitcase Simulator for EXPRESS Pallet
SE	Simulation Engineer
SIP	Standoff-mounted Interface Panel
SIR	Standard Interface Rack
SSE	Station Support Equipment
SSMTF	Space Station Mockup and Trainer Facility
SSTF	Space Station Training Facility
STEP	Suitcase Test Environment for Payloads
STFx	Simulator Test Fixture
SVMF	Space Vehicle Mockup Facility
T	Total Fidelity
TBD	To Be Determined
TBE	Teledyne Brown Engineering
TCS	Thermal Control System

TDS	Trainer Design Specification
TSC	Telescience Support Center
TST	Training Strategy Team
UIP	Utility Interface Panel
UOP	User Operational Facility
V	Visual Fidelity
Vac	Volts, Alternating Current
Vdc	Volts, Direct Current
VES	Vacuum Exhaust System
VRS	Vacuum Resource System
VS	Vacuum System
VSD	Video Switching and Distribution Subsystem

APPENDIX B

SIMULATOR CLASS LEVELS

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B, SIMULATOR CLASS LEVELS

B.1 SSTF/PTC FIDELITY CLASS DEFINITION

A system for classifying both PTUs and their individual components has been devised to help coordinate simulator requirements, approach, and capabilities. This system involves classifying integrated PTUs into five classes based on their overall design approach, as well as classifying the PTU components into five fidelity levels.

The five simulator classes are defined as follows:

Class I	Flight Equivalent Unit (FEU) - May be an engineering unit, a non-qualified flight item, or a non-radiation hardened Commercial Off-The-Shelf (COTS) equivalent
Class II	Software Simulation with Hardware Panels/Interfaces
	IIa - SW simulation in the SSTF Host computer (not currently supported)
	IIb - SW simulation in user-provided computer
Class III	Software Simulation with Virtual Panels/Interfaces
	IIIa - SW simulation in SSTF Host computer (not currently supported)
	IIIb - SW simulation in user-provided computer
Class IV	Hardware Panel Only
Class V	Inert Object - Picture or inert 3-D mockup.

The fidelity of the individual components that make up a PTU can be described by the following five levels. (Note that substitution of materials that does not impact training objectives is acceptable for all fidelity levels.)

A. Total Fidelity (T): All functional and physical characteristics of the payload elements will be representative of the flight design for use in the appropriate environment. Construction will be to flight article drawings with deviations allowed in materials, finishes, coatings, weld quality, and inspection requirements. Example: A control and display panel that has switches and displays will be identical in appearance and feel to the flight article and will respond correctly to operation of the controls. This fidelity also includes flight hardware that was procured for training purposes, backup flight hardware, or an engineering model.

B. Functional Fidelity (F): All functional characteristics of the payload elements will be representative of the flight design for use in the appropriate environment. Physical characteristics are not required. Example: A switch that does not have the same characteristics as the flight article, but does function to turn on the appropriate item of equipment. Another example is a software simulation driving a virtual panel or Cathode Ray Tube (CRT). All components are represented and, when operated, create the proper system response.

C. Physical Fidelity (P): All physical characteristics of the payload elements will be representative of the flight design for use in the appropriate environment. Functional characteristics are not required. Example: A control panel that has switches and knobs that are mechanically operable, having the same appearance and operating force and movement as the flight article, but which are not connected to produce a system response or display.

D. Envelope Fidelity (E): Exterior shape and color of the payload elements will be representative of the flight design. In general, this hardware is used to verify component location within the appropriate environment. Example: A wire bundle that is a volumetric representation for external appearance.

E. Visual Fidelity (V): Physical and functional characteristics are not required. Front panels in proper location representative of flight article, but are inert mockups or pictures/drawings of the flight panel. They have no operational switches/displays or functional software. Examples: Photograph mounted on life sized panel, a plastic/metal mockup painted to look like the flight item, drawing of the flight panel mounted in appropriate location for completeness of overall flight environment for training correctness.

B.2 SSMTF TRAINER FIDELITY CLASS

B.2.1 TERMINOLOGY

Simulator/trainer/mockup - An assembly of hardware alone or hardware and software in combination, configured to resemble some aspect of a flight element or piece of ground equipment.

Functionality - The degree of exactness of replication of stimuli and the responses to those stimuli by the simulator/trainer/mockup relative to the original article.

Class - Appearance, tolerance, and composition of a simulator/trainer/mockup as it relates to the original article.

B.2.2 FUNCTIONALITY

Four levels of functionality are required to fully address simulators/trainers/mockups.

A. Flight-type - The capability of utilizing de-rated or actual flight/ground hardware to replicate the stimuli, processes, and responses. Flight-type capabilities provide simulated flight data and communications with appropriate transmission protocols.

B. Functionally active - The capability of functionally replicating the stimuli, processes, and responses of the original article. Functionally active capabilities provide simulated data and communications, but need not use the same transmission protocols.

C. Operable - The capability of functionally replicating the stimuli and responses with limited process modeling. Data and communications are provided only to student and instructor.

D. Static - No active stimuli, processes, or responses.

B.2.2 CLASS

Three types of hardware are required to address the appearance, tolerance, and composition of simulators/trainers/mockups.

A. Class I

Flight Assembly Tolerance - Conforms to flight (or ground) article dimensions, but is not flight qualified.

Similar Materials - Materials are of same family and characteristics as the flight article, but are not necessarily the same grade.

Exact Configuration - Appearance is like flight article in all aspects.

Class I hardware is typically used for crew (or ground) training, or engineering verification exercises.

B. Class II

Relaxed Assembly Tolerance - Not held to flight specifications; margins to be specified by requirements documents.

Mixed Materials - Materials meet general characteristics of flight article and optimally support the intended function, but need not be of the same family, grade, or specification.

Approximate Configuration - Appearance is similar to flight article (size, shape, color, orientation, location, etc.).

Class II hardware is typically used for crew (or ground) training or design development.

C. Class III

Approximate Dimensions - Anticipated volumetric approximation.

Optional Materials - Materials support facility objective.

Configuration - Appearance to depict design or anticipated concept.

Class III hardware is typically used for concept formulation or preliminary layout. It is also used for portions of a training facility that do not require active student operations and would otherwise remain void. Example: a module window that crew training does not address.

TABLE B-1 SVMF SIMULATOR/TRAINER/MOCKUP CLASSIFICATION MATRIX

Functional Class	F. Flight-type	A. Functionally Active	B. Operable	C. Static
Flight-type	Flight equipment downgraded for training	N/A	N/A	N/A
I. Flight assembly tolerance Similar materials Exact configuration	N/A	I.A	I.B	I.C
II. Relaxed assembly tolerance Mixed materials Approx. configuration	N/A	II.A	II.B	II.C
III. Approximate dimensions Optional materials Appropriate configuration	N/A	III.A	III.B	III.C

APPENDIX C

INTEGRATED RACK PTU REQUIREMENTS

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C, INTEGRATED RACK PTU REQUIREMENTS

This appendix supplies requirements that are specific to an Integrated Rack (Facility Rack, EXPRESS Rack, or Lab Support Equipment Rack) payload that will be operated on board the International Space Station (ISS) and requires a simulator for training (as determined by the TST). The requirements provided in this appendix shall apply to all Integrated Rack Payloads, unless specifically waived by the Training Strategy Team (TST) for that payload.

C.1 PTU ARCHITECTURE AND INTERFACES

Figure C-1 provides a block diagram for a typical Integrated Rack PTU, depicting all major simulator components and interfaces between the PTU and the SSTF/PTC. The PTU shall interface with various SSTF/PTC resources and exchange information with various SSTF core systems models, as discussed in Section C.2. Detailed requirements for the hardware mockups and simulation software components of the PTU shown in Figure C-1 are provided in Sections C.4 and C.3.

The PTU shall be provided as a self-contained, ISPR-like rack with interfaces to the SSTF/PTC provided at the bottom of the rack. The PTU shall provide a rack that conforms to the requirements provided in Section 10.3.1 of the PUDG. Note that the PD is encouraged to use an SSTF-provided ISPR, as described in the PUDG, as the external structure for the PTU. The PTU shall provide a rack that conforms to the mechanical interface requirements provided in Section 30.4.3 of the PUDG. These interfaces are already incorporated in the SSTF-provided racks.

It is recommended that the PD make use of a combined Payload Simulator Environment (PSE)/Simulator test Fixture (STFx) platform for development of the PTU software. The PSE is a desktop computer system which contains hardware interfaces for 1553B bus, payload Ethernet, and PSimNet. The PSE/STFx also optionally provides discrete and analog cards for interface to rack mockup hardware as detailed in section C.2.1.5 of this appendix. The PSE /STFx provides pre-built interface handlers for 1553 bus, payload Ethernet, rack hardware (see Section C.2.1.5) and the PSimNet. PSE System specifications and other details can be provided to the PD by DK upon request. Drawings may be obtained from DK for modification of an SSTF-provided ISPR to incorporate the PSE in the bottom of the rack.

The PTU shall not require external control or support equipment to operate, all such equipment shall be contained within the rack volume. Note that this does not preclude stowage items or other training equipment, which are considered part of the PTU and may be used external to the rack. Also note that for testing and maintenance purposes, external control or support equipment is allowed, and access to the rack from the rear is available.

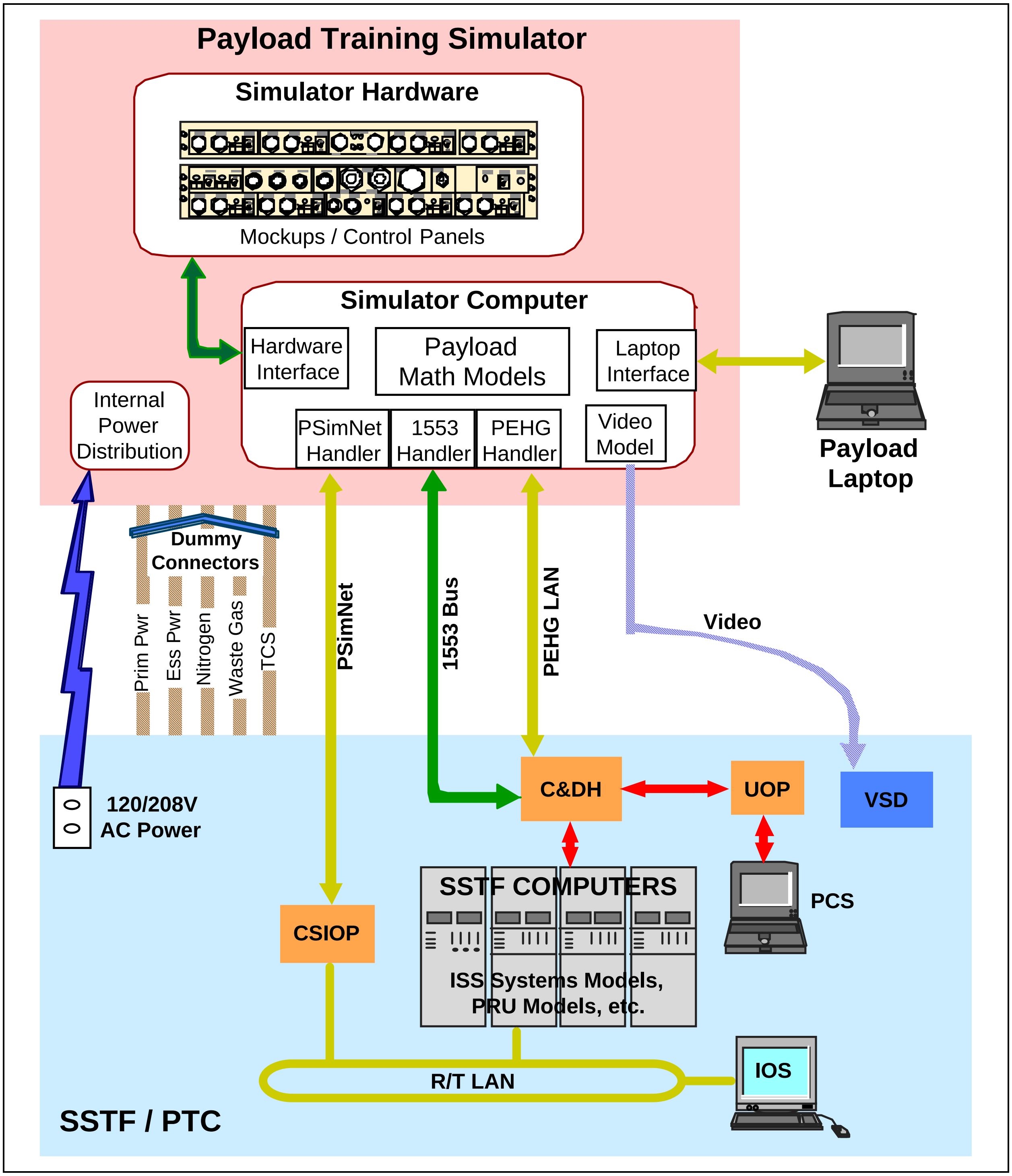

FIGURE C-1 TYPICAL INTEGRATED RACK PTU

C.2 RACK EXTERNAL INTERFACES

This section provides the requirements for the physical, electrical, and data interfaces between the PTU and the SSTF/PTC resources, as well as the PTU's simulated interfaces to the ISS core systems models in the SSTF/PTC. Also addressed are the requirements for the payload's values for the Payload Resource Utilization (PRU) models in the SSTF.

C.2.1 INTERFACES TO SSTF/PTC RESOURCES

The PTU will receive support from various SSTF/PTC resources. For each SSTF/PTC resource with which the PTU interfaces, the following sections provide a description of the resource and a description of the PTU's specific requirements. These interfaces shall comply with the SSTF-to-PTU interface specifications given in Appendix III of the PUDG.

C.2.1.1 Payload Ethernet LAN and Payload Ethernet Hub Gateway (PEHG)

The Payload Ethernets and PEHG emulation support communications from the PTU to other PTUs and to PCSs (if connected at the PEHG UOPs). The medium-rate data link is supported using the same interfaces as in flight. The medium- to high-rate telemetry gateway of the PEHG is simulated, but gateway-addressed packets entering the PEHG are discarded. The electrical interface specifications for the PEHG are provided in Section 30.4.4.2.1.1 of the PUDG.

The PTU shall provide a flight-like implementation of the Payload Ethernet LAN and PEHG interface. All message traffic shall be simulated, except that the content of the medium- and high-rate packages need not be simulated.

C.2.1.2 MIL-STD-1553B Bus

The flight-equivalent 1553 buses provide the interface to the emulated Multiplexer/ Demultiplexers (MDM), which will host actual C&DH flight software, including the Payload Executive Processor (PEP). The PTU will interface with the PEP emulator through a Remote Terminal (RT) interface on a payload 1553B bus. The RT address shall be determined as specified in Section 30.4.2.1 of the PUDG. The PEPs will execute ISS flight software, command and control payloads, and provide services to payloads as in flight. Note that the SSTF does not support the High-Rate Data Link (HRDL) and has limited support for low rate telemetry, as provided in Section 30.3.3.2.1 of the PUDG. The electrical interface specifications for the 1553 bus are provided in Section 30.4.4.2.2 of the PUDG.

The PTU shall provide a flight-like implementation of the 1553 interface. All message traffic shall be simulated, except that the content of the HDRL packages need not be simulated.

C.2.1.3 Payload Simulation Network (PSimNet)

The PTU shall interface with the SSTF/PTC for simulation-unique control and data through the PSimNet Ethernet connection. This interface will provide the PTU with all of its simulation control functions, which include the commands required to initialize, control, and insert malfunctions into the PTU. The PSimNet will also provide an interface between the simulator and the SSTF core systems simulators as detailed in Section C.2.2 of this appendix. The interface protocols for the PSimNet are provided in Section 30.3.3.6 of the PUDG, the logical interface specifications are provided in Section 30.4.2 of the PUDG, and the electrical interface specifications are provided in Section 30.4.4 of the PUDG.

The PTU shall implement the PSimNet interface to provide PTU control functions, PTU monitoring via the IOS, and SSTF core system simulator support. The PTU control functions shall include the commands required to initialize, control, and insert malfunctions into the PTU as detailed in Section 4 of this document. The PTU monitoring function shall provide sufficient visibility into the PTU's internal operations for an Instructor at the IOS to properly monitor those operations.

The Integrated Rack PTU shall provide support for all PSimNet traffic that may be required to be communicated to Sub-rack PTUs mounted within the integrated rack (e.g., mode control, malfunction flags). Likewise, the integrated rack shall gather health and status data from all Sub-rack PTUs and incorporate this into its own PTS Data Message as described in Section 30.4.2.3.5 of the PUDG for shipment to the SSTF IOS. Station resource utilization values reported by the rack to other SSTF station models shall be the sum of the rack itself and all active Sub-rack PTUs.

C.2.1.4 Portable Computer System (PCS)

The PCS is used to provide payload data and commanding capabilities from positions in the Lab other than the payload front panel or dedicated laptop computer. This computer is tied into the C&DH system via a 1553 interface or the PEHG LAN. The PCS will be loaded with the appropriate NASA-provided flight software for each increment.

The PTU shall provide a flight-like implementation of the PCS interface, either through the 1553 or the PEHG LAN, as appropriate. All commands from the PCS and data to the PCS shall be simulated.

C.2.1.5 Signal Conversion Equipment (SCE)

The SCE provides for I/O interfaces between the hardware signals from the payload simulator hardware and computer based software. This interface is between the PD-provided PTU platform and rack. Data types involved in SCE interfaces include discrete inputs, discrete outputs, analog inputs, and analog outputs. The PD is responsible for providing interfaces between the PTU software model platform and rack hardware. The PSE provides hardware and interface driver software for this function as an optional pre-built package.

C.2.1.6 Video Switching and Distribution (VSD) Subsystem

The VSD subsystem provides capabilities for routing video signals between the PTU and other training facilities. Connectors for NTSC composite RS-170 video are available at each rack interface. Video generated by the PTU can be viewed in the SSTF at an IOS or on monitors in the briefing/debriefing rooms. Video can also be routed to other locations, including MCC-H and the POIC.

If available from the real payload, the PTU shall output one RS-170 video signal to the SSTF/PTC rack interface. This video signal shall contain the appropriate imagery, either generated in realtime or pre-recorded, to provide the trainee with flight-like visual feedback of his or her actions or with feedback of the payload's operations in realtime.

C.2.1.7 Electrical Power

The SSTF facility provides electrical power and ground to each rack location. One five-wire connector (NEMA L21-20) will supply 120/208 Vac 3-phase power at 20 A. The electrical power connection specifications are defined in Section 30.4.4 of the PUDG. A power strip terminal is located on the internal surface of the IIP that includes ac power and SSTF multi-point safety-ground connections for the PTU. Note that although a 20-A circuit is provided, cooling and ventilation is only provided for 2 kW of power dissipation for each rack location. Also note that the cooling fan assembly provided by the SSTF is pre-wired to the terminal strip and draws 0.52 A at 120 Vac.

The PTU shall be constructed to operate from the available SSTF power resources described above, and shall be limited to 2 kW of power dissipation.

C.2.1.8 Fire Detection System

The PTU shall implement rack fire detection as described in Sections 4.5.3.4 and 30.4.4.4 of the PUDG.

C.2.2 INTERFACES TO CORE SYSTEMS MODELS

This section addresses the interfaces between the PTU and the ISS core systems models. These models provide simulated resource support to the payload simulators as well as serving as training tools on the ISS subsystems, and are described in Section 4.5 of the

PUDG. The PTU shall be responsible for updating the data provided to the core systems models over the PSimNet, as specified below..

An Integrated Rack PTU shall model the resource utilization for both the rack and its resident sub-rack payloads, regardless of whether those payload's simulators are actually installed. The PTU's model of payload resource usage can be a simple table-driven model dependent on the power status of each payload, or it can be a more complex model taking into account the specific operational status of each payload. The PTU software shall provide data to the core systems models regardless of the power status of the payload being simulated.

The following sections provide the requirements for the interfaces between the PTU and the core systems models. The data for each model discussed below will be exchanged at a rate of 1 Hz.

C.2.2.1 Electrical Power System (EPS) Model

The EPS model (see Section 30.3.3.1 of the PUDG) provides a power status to the PTU for both the main bus power and the essential bus power available to the rack. This simulation includes the emulation of the on-board utility outlet panels and a simulation of the power available to the payload. The EPS model reports the current voltage available on the main and essential buses in volts, dc. The PTU shall supply the EPS model with the real-time power load on the main and essential buses in watts. Since the real electrical power supplied to the PTU is not interactive with the power status provided by the EPS (power supplied to the PTU is continuous, to run PTU systems), the PTU shall make the payload appear interactive based on the power status received from EPS.

C.2.2.2 Thermal Control System (TCS) Model

The TCS model (see Section 30.3.3.1of the PUDG) is a hardware and software simulation of the thermal control functions on board Space Station. The hardware simulation consists of dummy coolant lines and connectors that will mate with the PTU. Coolant supply and return line temperatures and flow rates are simulated dynamically. The TCS shall provide the flow rates in pounds per second and temperatures in degrees Fahrenheit for the moderate and low temperature cooling loops to the PTU. The PTU shall provide the TCS with the heat load, in Btu's per second, currently being added into the appropriate cooling loop.

C.2.2.3 Environmental Control and Life Support System (ECLSS) Model

The ECLSS model (see Section 30.3.3.1of the PUDG) provides a software simulation of the atmosphere of the U.S. Lab, the Lab Nitrogen System (LNS), and the Vacuum System (VS). The cabin air temperature model includes the simulation of cooling air and heat loading at each ISPR location. ECLSS shall provide the PTU with the cabin temperature in degrees Fahrenheit and pressure in psi. The PTU shall provide ECLSS with the amount of heat being dumped to cabin air in Btu's per second.

The LNS model is a hardware and software simulation of the nitrogen system to the ISPRs. The hardware simulation consists of dummy nitrogen lines and connectors to the PTU, including both the LNS main line and the LNS standoff lines. The LNS software model will simulate the gaseous nitrogen flow rate to any ISPR location in the U.S. Lab module. As part of this simulation, LNS shall provide the PTU with the nitrogen pressure available in psi. The PTU shall provide the LNS with the amount of nitrogen used in pounds per second.

The VS model is a hardware and software simulation of the Vacuum Exhaust System (VES) and Vacuum Resource System (VRS) valves and sensors, the Guide valve, and motor operated valve Guide override capability. VS software simulates normal operations, safeguard operations, maintenance, and shutdown modes dynamically. The VS model shall provide the current VES and VRS simulated vacuum pressures at each ISPR location to PTU in psi. The PTU shall provide the rate of gas exhausted to the VES and VRS from the payload as a flow rate measured in pounds per second.

C.2.2.4 On-Board Computer System Model

The OBCS model consists of a combination of hardware and software components that provide a full system signature simulation of the ISS on-board C&DH system and its interface components, including the ISS PCS (see Sections 4.5 and 30.3.3.2 of the PUDG). The OBCS supports ISS systems command and control, supports ISS payload users, and provides services for flight crew and ground operations. The OBCS simulates the MDM which provides data processing and transfer for data. Since the OBCS model runs the actual Flight Software (FSW), data processing capabilities will duplicate those available on orbit. The SSTF OBCS simulates the HRDL, but does not support the TAXI for payload-to-payload communications or payload downlink through Ku-band.

The PTU shall support all low-rate data that is present in its 1553B flight data stream including health and status data. Low-rate health and status data that will be downlinked in flight via Ku-band is handled by a simulation-unique line that transfers low-rate payload health and status data to the MCC and subsequently to the POIC for demultiplexing and conversion to engineering units.

C.2.2.5 Communications and Tracking (C&T) Model

The C&T model uses a combination of hardware and software to simulate the services provided via S-band and Ku-Band (see Section 4.5 of the PUDG). C&T supports all uplink and downlink capabilities of the S-band link, and the functions of the Ku-band link used to support the downlink of payload health and status and video data with the exception of HRDL capabilities. The C&T model provides Acquisition Of Signal (AOS)/Loss Of Signal (LOS) status for both S-band and Ku-band. Use of the C&T model is transparent to the PTU, therefore requiring no specific simulator interfaces.

C.2.2.6 Guidance, Navigation, and Control (GN&C) Model

The GN&C models the flight GN&C system, providing the generation of state vectors, attitude, and pointing support data (see Section 4.5 of the PUDG). The PTU simulator shall not require the SSTF GN&C model.

C.2.3 PTU INTERFACE TO SUB-RACK PAYLOADS

The PD shall provide an Integrated Rack Simulator Interface Definition Document (IDD) that details the simulator unique rack to subrack interfaces discussed in Section 5.1 of this document. This document will be distributed by the rack facility PD to those PDs that are responsible for the development of individual Sub-rack PTUs.

C.2.3.1 Payload Ethernet Hub Bridge (PEHB)

The PTU shall provide the necessary flight-like Ethernet interfaces to support the crew’s interfaces via the Rack Laptop and/or the PCS, as well as to support payload commanding, data communication, and PEHB reconfiguration by the crew or GSP. The PTU shall implement the communications protocols through the Ethernet Hub/Bridge required to support a flight-like ISS and Sub-rack payload interface.

C.2.3.2 RS-422 Serial Interface

The PTU shall provide the necessary flight-like RS-422 interfaces to support the crew’s interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command, monitoring, and reconfiguration by the crew or GSP. The PTU shall implement the communications protocols through the RS- 422 required to support a flight-like ISS and Sub-rack payload interface.

C.2.3.3 Analog and Discrete Communications

The PTU shall provide the necessary flight-like analog and discrete communications to support the crew’s interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command, monitoring, and reconfiguration by the crew or GSP.

C.2.1.7 Video

The PTU shall support the necessary flight-like, configurable video switch interface to Sub-rack PTUs to support GSP and crew monitoring of Sub-rack PTU video in a flight-like manner. The PD must supply the means to deliver this video to the Rack laptop or Rack-to-Station interface as specified in the PUDG.

C.2.4 DATA FOR PRU MODELS

For systems training when the PTU is not included in the training session configuration, the SSTF has the capability to use PRU software models to provide a minimum set of state and consumption data to simulate the load that payload would place on the ISS systems resources. PRU models are described in Section 4.9 of the PUDG, and the PRU Form that is used to collect the information needed to develop the models is provided in Section 30.5 of the PUDG. The PD shall provide the information to the Engineering and Integration Agreement Data Set in PDL by I-18 months.

C.3 PTU SOFTWARE REQUIREMENTS

The Integrated Rack PTU software shall provide flight-like interfaces to the crew and ground controllers by responding to commands and providing monitoring data through the 1553 bus, the PEHG LAN, the video link, and directly to the payload’s front panels. The software shall accept command inputs from the SSTF executive processor via the 1553 bus and modify the payload processing parameters appropriately. The Integrated Rack PTU shall support the flight-like command and data requirements of any Sub-rack PTU. In addition, the Integrated Rack PTU shall extend the PSimNet interface to Sub-rack PTUs. These software interfaces to Sub-rack PTUs shall be documented in a PD-supplied IDD.

C.3.1 SIMULATION OF MALFUNCTIONS

Control for malfunctions shall be initiated at the IOS and input to the PTU software via messages through the PSimNet. The specifications for these malfunction messages are provided in Section 30.4.2.3.6 of the PUDG. The PTU software shall respond to the malfunction messages directed at the rack itself by modifying its data processing so that the data output indicates the existence of the malfunction. The Integrated Rack PTU shall maintain a table of malfunction flags for supported Sub-rack PTUs and shall pass these malfunction messages to the appropriate Sub-rack PTU. The malfunction shall be reset by a reset message from the IOS.

Malfunction requirements shall be provided to the SE by I-17 for incorporation in the PTU-specific PSRD, Volume II, as defined in Section 30.6 of the PUDG, so that the required messages can be generated.

C.3.2 SIMULATION OF PEP INTERFACES

This section discusses the SSTF/PTC emulation of the Payload Executive Processor (PEP) and the Payload Executive Software (PES) that provide command, control, and monitoring functions used by the PTU. The communication for these functions shall occur over the 1553 bus. Commands shall be accepted by the PEP emulation and passed on to the PTU processor for processing. Data shall be output by the PTU to the PEP for on-board monitoring and for downlink.

The PTU shall output a simulated health and status data stream through the 1553 bus. A command rate of one command per second shall be supported by the SSTF/PTC-to-PTU link. The PTU processor shall conform to standard ISS data protocol. In addition, simulated health and status data variables shall be included in PTS data messages sent through the PSimNet for monitoring at the IOS.

The training version of the PES, which is a duplication of the flight load, will be provided by the SSTF/PTC. After being processed by the PES, output data shall be made available on the 1553 bus for shipment to the Command and Control MDM and the PCS. If applicable, the PTU shall require the use of payload specific data files that run in conjunction with the PES. These data files allow the PTU to take advantage of the PES capabilities to display and monitor data.

Some payloads require the use of Payload Application Software (PAS) that operates in the PEP to perform additional processing on its output data parameters. The training version of this software will be provided by the SSTF/PTC, and will be a duplication of the flight load. The PTU shall provide a flight-like interface to any PAS used by the payload.

C.3.3 IOS DISPLAY AND COMMAND REQUIREMENTS

In order to monitor internal operations of the Integrated Rack PTU and supported Subrack PTUs during a training session the simulator shall output parameters through the PSimNet to be viewed on the IOS. Note that these parameters may not be normally output by the real payload but are useful for keeping track of the status of the simulator. These parameters shall include sufficient information to monitor the status of any rack hardware elements, malfunctions, and software operations. The Integrated Rack PTU will append IOS display information from Sub-rack PTUs into its own PTS data message as described in Section 30.4.2.3.5 of the PUDG. These parameters shall be defined to the SE as detailed in Section 30.5 of the PUDG. PTU mode control as well as malfunction messages also originate from the IOS. These functions are discussed in Section 4 of this document. The PD shall provide data for the development of the command and display data tables to the Payload Data Set.

C.4 INTEGRATED RACK HARDWARE REQUIREMENTS

This section identifies the PTU mockup hardware components required to support training activities. An Integrated Rack PTU shall be provided as a self-contained, ISPR-like rack with interfaces to the SSTF/PTC provided at the bottom of the rack. The operational interfaces with the crew, and their physical interfaces with the ISS Lab module mockups that are unique to the Integrated Rack PTU will be discussed in the following sections hardware requirements that are common to all PTUs are defined in Section 5 of this document.

C.4.1 PTU INTERFACE CABLES

The SSTF/PTC will provide interface cables between the ISPR-mounted Interface Panel (IIP), which is a simulator unique panel, and the Standoff-mounted Interface Panel (SIP), which corresponds to the Utility Interface Panel (UIP) in the real U.S. Lab. If a PTU rack does not include an IIP, the PD shall provide the interface cables between the PTU and the SIP. Section 30.4.3.2 of the PUDG provides information about the physical interfaces, in particular descriptions of the IIP and the SIP.

The PD shall provide interface cables to connect the PTU hardware to the IIP or SIP connectors for the 1553 bus, the PEHG, the PSimNet, etc. The pin out specifications for these cables shall comply with the specifications provided in Section 30.4.3.2.4 of the PUDG. The PD shall also be responsible for providing the cables required to interconnect the internal components of the PTU, or to connect any components (including Sub-rack PTUs) external to the rack with the rack.

C.4.2 PTU RACK HARDWARE FOR TILT OPERATIONS TRAINING

The SSTF/PTC does not allow training for crew operations that involve tilting an ISPR rack. For those rack facilities that require tilt operations as part of ORU or experiment-unique installation training, the PD must supply a second, non-powered, hardware-only training unit for use in the SVMF in Building 9 at JSC. The PTU shall be designed to interface with the Building 9 module mockups in accordance with interface drawing SK683-29204. This drawing can be obtained from the facilities manager for the SVMF. The PTU for the SVMF shall include all non-payload, on-orbit accessible internal rack ORUs with proper flight-like dimensions and attachment points for structural interfaces and substructure (cabling, fluid lines, etc.) as determined by the TST process.

The PTU supplied to the SVMF shall have a PD-provided, counterbalanced rack rotation assembly. The rack rotation assembly shall be capable of rotating to a minimum extension of 80 degrees relative to the vertical when the ISPR is fully configured with all the ORU components, holding that position, and then returning to its non-rotated position without any functional degradation of the mechanism. The rack rotation assembly shall have a structural factor of safety greater than 4.0.

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APPENDIX D

INTEGRATED EXPRESS SUB-RACK PTU REQUIREMENTS

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D, INTEGRATED EXPRESS SUB-RACK PTU REQUIREMENTS

This appendix supplies requirements that are specific to an integrated EXPRESS Sub-Rack (Middeck Locker (MDL) or ISIS drawer) payload that will be operated on board the International Space Station (ISS) and that requires an integrated simulator for training. The requirements provided in this appendix shall apply to integrated EXPRESS Sub-rack payloads, unless specifically waived by the Training Strategy Team (TST) for that payload.

D.1 PTU ARCHITECTURE AND INTERFACES

Figure D-1 provides a block diagram for a typical Sub-rack PTU, depicting all major simulator components and interfaces between the PTU and the EXPRESS Rack Simulator. The PTU will interface with various EXPRESS Rack resources and exchange information with various rack systems models, as discussed in Section 4. Detailed requirements for the hardware mockups and simulation software components of the PTU shown in Figure D-1 are provided in Sections 5 and 4.

The PTU shall be provided as a self-contained MDL or ISIS drawer mockup with flight-like front panel (or other) interfaces to the EXPRESS Rack provided. The PTU shall not require external control or support equipment to operate; all such equipment shall be contained within the rack volume. Note that this does not preclude stowage items or other training equipment, which are considered part of the PTU and may be used external to the rack. Also note that for testing and maintenance purposes, external control or support equipment is allowed.

D.2 PTU EXTERNAL INTERFACES

This section provides the requirements for the physical, electrical, and data interfaces between a Sub-rack PTU and the EXPRESS Rack resources, as well as the PTU's simulated interfaces to the EXPRESS Rack systems models.

D.2.1 INTERFACES TO RACK RESOURCES

The EXPRESS Rack Simulator will support a wide range of Sub-rack PTUs. These PTUs will range from engineering units that operate with flight software loads to simulators that only support basic payload commanding and operation through a front panel or the EXPRESS Laptop. The EXPRESS Rack Simulator will support power, data, and video interfaces to the payload locations within the rack. For each EXPRESS Rack resource with which the PTU interfaces, the following sections provide a description of the interface, which shall comply with the EXPRESS Rack-to-payload simulator interface specifications given in the EXPRESS Rack Simulator IDD as specified in Section 3.4 of this document.

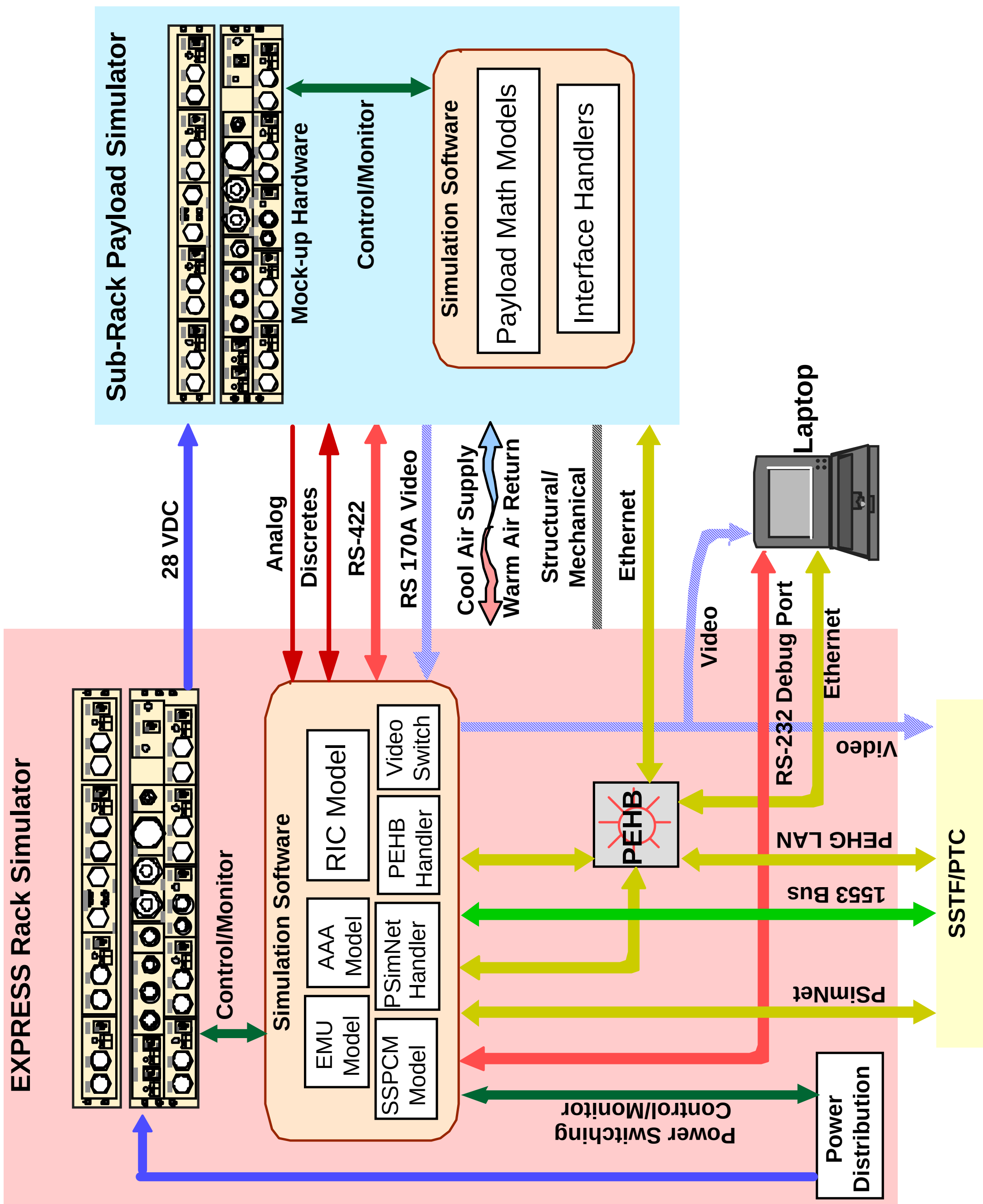

FIGURE D-1 TYPICAL SUB-RACK PTU

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D.2.1.1 Rack Interface Controller (RIC) Model

The PTU shall provide the necessary flight-like interfaces to the RIC model to support the crew's interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command and monitoring by the GSP. The PTU shall simulate the communications protocols with the RIC model required to support the flight-like interfaces. The PTU shall output a simulated health and status data stream through the RIC datalink (RS-422 or Ethernet.)

D.2.1.2 Payload Ethernet Hub Bridge (PEHB)

The PTU shall provide the necessary flight-like Ethernet interfaces to support the crew's interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command and monitoring by the GSP. The PTU shall simulate the communications protocols through the Ethernet required to support the flight-like interface.

D.2.1.3 RS-422 Serial Interface

The PTU shall provide the necessary flight-like RS-422 interfaces to support the crew's interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command and monitoring by the GSP. The PTU shall simulate the communications protocols through the RS-422 required to support the flight-like interface.

D.2.1.4 Analog and Discrete Communications

The PTU shall provide the necessary flight-like analog and discrete communications to support the crew's interfaces via the EXPRESS Laptop and/or the PCS, as well as to support payload command and monitoring by the GSP.

D.2.1.5 Payload Simulation Network (PSimNet)

There is only one PSimNet interface to each ISPR location in the SSTF; thus the EXPRESS Rack Simulator shall receive PSimNet commands addressed to a rack location and distribute those commands to the appropriate subrack PTU within the rack. The EXPRESS Rack Simulator will extend the PSimNet's interface to Sub-rack PTUs for control and monitoring. The EXPRESS Rack Simulator will provide loading information to the SSTF/PTC via the PSimNet that reflects both rack and Sub-rack payloads consumption, regardless of the fidelity or even the presence of the payload simulators. Therefore, individual EXPRESS payload PTUs are required to pass simulated systems loading information to the RIC as specified in the EXPRESS Rack Simulator IDD.

D.2.1.6 EXPRESS Laptop

The Sub-rack PTU shall support the necessary flight-like interfaces to accept commands from the Laptop and to supply data to the Laptop displays. Copies of any payload unique software that runs on the flight EXPRESS Laptop shall be provided by the PD as part of the Sub-rack PTU.

D.2.1.7 Video

The PTU shall support the necessary flight-like video interface to the EXPRESS Rack Simulator to support science gathering and crew monitoring if these functions are required for training. The PD must supply the means to deliver this video to the rack interface as part of the subrack PTU (videotape player, CD-ROM player, etc.).

D.2.1.8 Electrical Power

The PTU shall be built to operate with the power available from the EXPRESS Rack Simulator. The PTU shall respond to the switched 28-Vdc supply for power on/off status, even if the PTU does not otherwise use this power to operate.

D.2.2 INTERFACES TO SIMULATED RACK RESOURCES

If a Sub-rack PTU makes use of vacuum, nitrogen, or cooling water resources in its simulation of the real payload, then it shall report this information to the EXPRESS Rack RIC as specified in the EXPRESS Rack Simulator IDD. The subrack simulator shall provide this data regardless of the simulated power status of the rack or of the Sub-rack payload.

D.3 SUB-RACK PTU SOFTWARE

This section specifies the software capabilities required for a Sub-rack PTU to operate within the EXPRESS Rack and the SSTF/PTC simulation environment. The PTU shall have PD-provided software that simulates all major aspects of the flight payload processor and also provides simulation-unique functions. The PTU software shall reside in a PD-provided processor or in an EXPRESS Rack PTU Payload Simulator Environment (PSE), and shall provide a flight-like representation of the operations and interfaces of the payload. The software shall provide flight-like interfaces to the crew and ground controllers by responding to commands and providing monitoring data through the RS-422 Link, the PEHB, the Analog and Discrete Signals, the video link, and directly to the payload’s front panels. The software shall accept command inputs from the EXPRESS Rack’s RIC Simulator via the RS-422 and the PEHB and modify the payload processing parameters appropriately.

Any software targeted for a processor internal to the PTU shall be provided by the PD. The PD shall also provide a copy of any software intended for the EXPRESS Laptop or any payload-specific software intended for use on a station PCS.

The PTU software shall interface with the EXPRESS Rack Simulator and with the SSTF/PTC through an extension of the PSimNet to perform initialization, mode control, and malfunction insertion. The interface specifications for the EXPRESS Rack PSimNet extension are provided in EXPRESS Rack Simulator IDD as specified in Section 3.4 of this document.

D.3.1 SIMULATION OF NOMINAL OPERATIONS

The EXPRESS Sub-rack PTU software shall provide simulation of the nominal operations of the payload that involve crew interactions, either through hardware elements or through software displays. Operations that shall be simulated include, but are not limited to, activation/deactivation, hardware setup, calibration, sample changeout, science gathering, and data and video management. The PTU shall also support control and monitoring of the payloads operations from the ground. The PTU software shall respond to changes in EXPRESS Rack resources (real power; simulated vacuum, nitrogen, and cooling water) by exhibiting the appropriate response in the payload’s status.

D.3.2 SIMULATION OF MALFUNCTIONS

Malfunction requirements shall be provided to MSFC as defined in EXPRESS Rack Simulator IDD so that the required tables can be built into the EXPRESS Rack PTU database.

D.4 EXPRESS SUB-RACK HARDWARE REQUIREMENTS

This section identifies the Sub-rack PTU mockup hardware components required to support training activities. A Sub-rack PTU shall be provided as a self-contained MDL or ISIS drawer with interfaces to the EXPRESS Rack Simulator provided through the front of the rack. The PTU hardware components, as well as their operational interfaces with the crew and their physical interfaces with the EXPRESS Rack Simulator will be discussed in the following sections.

D.4.1 RACK-MOUNTED COMPONENTS

The EXPRESS Rack Simulator will provide primary and secondary structures with ISIS slide rail assemblies. The ISIS drawer interface in the back of the rack will provide flight-like power and data connectors with the corresponding pinouts as defined in Table 8-II (power) and Table 9-II (data and video) of the EXPRESS Rack Payloads Interface Definition Document (SSP 52000-IDD-ERP). The ISIS slide rail assemblies will accommodate two

4-PU ISIS drawers within the rack. EXPRESS Rack backplates for mounting MDLs will be provided with flight-like hole patterns for payload attachment in both the upper and lower MDL locations. The locker or drawer that contains the Sub-rack PTU shall be designed to integrate to the rack in a flight-like manner, conforming to the IDD listed above.

D.4.2 PTU INTERFACE CABLES

Resources for the Sub-rack PTU, including 28-Vdc switched electrical power, 120-Vac unswitched electrical power (simulator unique, not flight-like), and cooling air distribution, will be provided by the EXPRESS Rack Simulator Rack as described in EXPRESS Rack Simulator IDD as specified in Section 3.4 of this document.

The PD shall provide the interface cables between the EXPRESS Rack Simulator and the PTU. The EXPRESS Rack Payloads Interface Definition Document (SSP 52000-IDD-ERP) provides specifications for the physical interfaces, in particular descriptions of the connectors on the upper and lower connector panels. Flight-like cables (total fidelity) shall be provided for the power, data, and video connections to the Connector Panels. Simulated (physical fidelity) cables shall be provided by the PD, if appropriate, for the vacuum, water loop, or nitrogen gas connections to the connector panels.

D.5 EXPRESS SUB-RACK PTU DEVELOPMENT AND VERIFICATION PROCESS

The PTU development and verification process for EXPRESS Sub-rack PTUs shall be as described in Section 6 of this document and in addition, shall follow the PTU unique requirements detailed in this section.

D.5.1 PTU DEVELOPMENT

The PD shall develop the PTU based on the operational and interface requirements specified in this PSRD and, by reference, in the EXPRESS Rack Payload IDD and the PUDG. Development of the PTU’s EXPRESS Rack interfaces shall be performed using the Suitcase Simulator for EXPRESS (ScS-E), provided as GFE. The PD shall provide design specifications of the PTU, containing detailed information of the PTU’s capabilities, as part of the payload’s PDR package.

Prior to delivering the PTU to the SSTF/PTC, the PD shall host an representative to conduct a Simulator Pre-Shipment Test. The purpose of this test shall be to insure that the PTU meets the operational and interface requirements contained in the PSRD/ EXPRESS Rack Payload IDD/PUDG. The test shall be conducted using the applicable portions of the Payload Simulator Test Procedures (PSTP), developed by MSFC. The test shall be conducted with the PTU integrated with the ScS-E to provide an end-to-end verification of the simulator’s interfaces to the EXPRESS Rack. Problems encountered during the

Simulator Pre-Shipment Test shall be corrected by the PD prior to shipping the PTU to the SSTF/PTC.

The PD shall be responsible for crating and shipping to the SSTF/PTC the PTU components as specified in the PUDG. Those components of the PTU which are considered “hand-carried” (e.g., those non-integrated components that have other uses or that are expendables), shall be delivered to the SSTF/PTC at least 24 hours prior to the training sessions. The configuration and installation of the PTU components into the EXPRESS Rack shall be as detailed in the EXPRESS Rack Payload IDD. Any payload specific installation instructions will be included in the PD-provided PTU User’s Guide.

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APPENDIX E

STAND-ALONE PTU REQUIREMENTS

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E, STAND-ALONE PTU REQUIREMENTS

This appendix supplies requirements that are specific to a Stand-alone Payload that will be operated on board the International Space Station (ISS) and that requires a PTU for training. The requirements provided in this appendix shall apply to the PDs for all Stand-alone Payloads, unless specifically waived by the Training Strategy Team (TST) for that payload.

E.1 SAT ARCHITECTURE

Figure E-1 provides a block diagram for a typical Stand-Alone Trainer (SAT), depicting all major simulator components, interfaces, and environments. Detailed requirements for the hardware mockups and simulation software components of the SAT shown in Figure E-1 are provided in Sections 4 and 5. The SAT shall be provided as a self-contained locker or drawer mockup with flight-like front panel (or other) crew interfaces.

E.2 SAT HARDWARE REQUIREMENTS

This section provides the requirements for the hardware components of the SAT. These components, their crew interfaces, and their facility interfaces will be discussed in the following paragraphs. Figure E-1 depicts the layout for a typical SAT as it will be set up for training in the SSTF/PTC (or other training facility). This section also provides specifications for support equipment and resources that can be required from the SSTF/PTC.

E.2.1 MOCKUP UNIT

The Mockup Unit of the SAT shall include all panels and other components through which the crew controls and monitors the payload. The Mockup Unit shall operate on 120-Vac, 60-Hz power available from the training facility. Any special power requirements, such as 28 Vdc, shall be provided by the PD as part of the SAT.

E.2.2 OPERATOR’S CONSOLE

Note that all SATs will not require a separate Operator’s Console, but may instead provide a combined Mockup/Operator’s Console Unit. The Operator’s Console, if applicable, shall provide an interface (typically a monitor, keyboard, and mouse) through which the operator shall control and monitor the SAT. If not included in the Mockup Unit, the Operator’s Console shall house the CPU that provides the functional simulation of the payload.

The Operator’s Console shall operate on 120-Vac, 60-Hz power available from the training facility. Any special power requirements, such as 28 Vdc, shall be provided by the

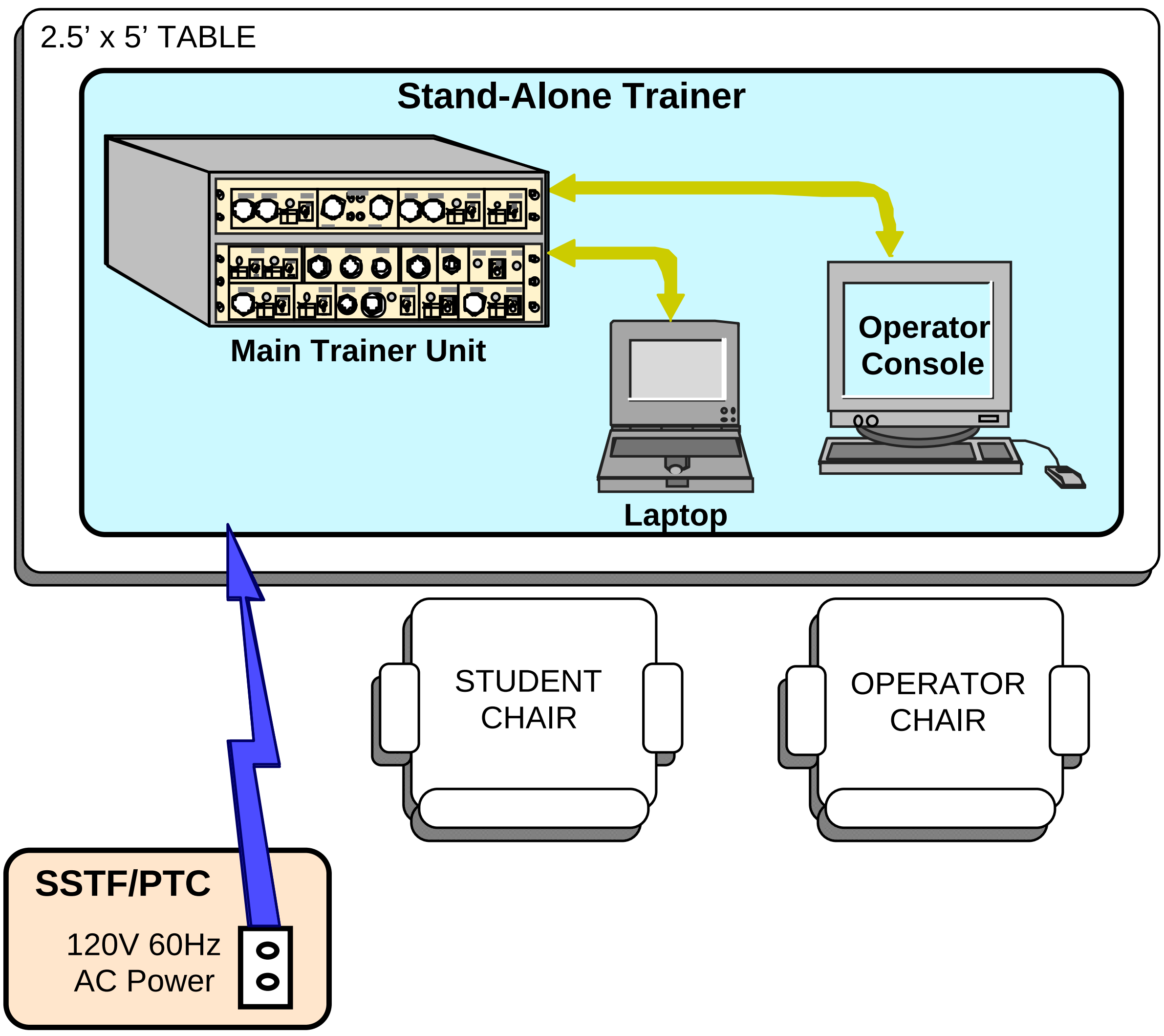

FIGURE E-1 TYPICAL SAT

PD as part of the SAT. The Operator's Console shall interface to other components of the SAT through PD-provided data cables.

E.2.3 LAPTOP

The PD shall provide a total fidelity Laptop, if applicable, to simulate the crew interface provided by the EXPRESS Rack Laptop or a payload-specific Laptop in flight. If simulating a payload-specific Laptop, the Laptop shall connect to the Mockup Unit via total-fidelity, PD-provided data and power cables. If simulating an EXPRESS Rack Laptop, the Laptop may connect to the Mockup Unit or Operator's Console via generic (non-flight-like), PD-provided data and power cables.

E.2.4 MISCELLANEOUS COMPONENTS

The PD shall provide any components associated with the payload with which the crew is required to interface as part of the SAT. This includes any stowage items such as experiment samples, handling equipment, spares, etc., that are required to meet any of the training objectives. If any non-payload components are required for the crew to perform their operations, such as ISS or EXPRESS Rack items, the PD shall negotiate with the DTM for these to be made available for training sessions. These hardware requirements shall be included in the PIDS as part of the PDR and CDR data package.

E.3 FACILITY RESOURCE REQUIREMENTS

The SAT shall use support equipment and resources specified in this paragraph from the SSTF/PTC to operate in support of crew training. The equipment and resources specified in this paragraph are considered normally available, e.g., furniture and electric power; any specialized support equipment shall be provided by the PD as part of the trainer or shall be specifically negotiated with the MSFC and DK representatives.

E.3.1 FLOOR SPACE AND FURNITURE

The SAT shall have access to one SSTF/PTC-provided table to support its components. If a rack, cabinet, or other enclosure is required, it shall be provided by the PD. Two chairs shall be provided by the SSTF/PTC, one for the operator/instructor and one for the student. All furniture shall be placed in a 8 ft by 10 ft (approximately) floor area to provide access to the "rear" of the equipment for setup and maintenance of the SAT as well as access to the "front" of the equipment for the instructor and student.

E.3.2 ELECTRICAL POWER AND OTHER RESOURCES

The SSTF/PTC will provide one electrical power outlet capable of supplying 120 Vac, 60 Hz, 8 A to each SAT. The SAT shall be provided with one standard, 3-prong, grounded plug to connect to the SSTF/PTC; multiple components of the SAT may be connected to a power strip, which in turn is connected to the facility.

Any additional resources required by the SAT, such as cooling, video interfaces, etc. shall be determined through the TST process. These resources shall not be normally provided for SATs.

E.4 SAT FUNCTIONAL REQUIREMENTS

This section provides the requirements for the functional characteristics of the SAT. The SAT shall include PD-provided software integrated with the hardware components to simulate all major aspects of the flight payload that are interactive with the crew. The SAT software shall reside on a PD-provided CPU and shall provide a complete, flight-like representation of the on-board operations of the payload from the crew’s perspective.

E.4.1 MODES OF OPERATION

The SAT shall be operated from the Operator’s Console (or the Mockup Unit) and shall have the capability to be operated in the following modes: Initialize, Hold, Run, Fast Forward, and Terminate. Note that for SATs that consist of engineering mockups or other flight-equivalent units this requirement may be waived by negotiations through the TST.

The Initialize mode shall provide the capability to power up and configure the SAT for a training session. The Hold mode shall provide a “pause” capability such that any time-related events being simulated do not advance. The Run mode shall be the normal simulation mode where all time-related events, those nominal and off-nominal functions specified below, occur in “realtime.” The Fast Forward mode shall allow any time-related event to occur at 2-60 times “realtime,” such that any long processes may be completed quicker for training purposes. The Terminate mode shall provide the capability to stop the simulation and power off the SAT in a controlled manner.

E.4.2 NOMINAL FUNCTIONS

The SAT software shall support training on those nominal operations on which the crew has control inputs or may be required to monitor. The SAT software shall simulate the operation of any internal elements of the payload to the extent that they are visible to the crew. This includes a functional simulation of all elements of any payload panels as well as all displays and commands available on the Laptop.

E.4.3 SIMULATION OF MALFUNCTIONS

The SAT software and hardware shall provide simulation of malfunctions that involve crew safety or hazards, require rapid response to protect payload equipment or samples, or affect elements of the ISS external to the payload. Malfunctions involving broken hardware shall either be provided via software simulation of the malfunction’s effect, or, if more appropriate, via a broken component that can be substituted for the unbroken component in the SAT.

Command and monitoring of malfunctions shall be initiated at the Operator’s Console or the Mockup Unit, as appropriate. The SAT software and/or hardware shall respond to the malfunction command by modifying its processing so that the data output to the crew interface indicates the existence of the malfunction. The malfunction shall be reset by either the performance of the proper malfunction procedures or by a reset message from the operator.

Note that for SATs that consist of engineering mockups or other flight-equivalent units the requirement to support malfunctions may be waived by negotiations through the TST.

E.5 SAT DEVELOPMENT AND VERIFICATION PROCESS

The PTU development and verification process for stand-alone trainers shall be as described in Section 6 of this document and, in addition, shall follow the PTU unique requirements detailed in this section.

E.5.1 SAT DEVELOPMENT

Prior to delivering the trainer to the SSTF/PTC, the PD shall host an representative to conduct a Trainer Pre-Shipment Test. The purpose of this test is to insure that the SAT meets the requirements in this TDS. Problems encountered during the Trainer Pre-Shipment Test shall be corrected by the PD prior to shipping the SAT to the SSTF/PTC.

Note that the Trainer Pre-Shipment Test may not be required, depending on the complexity of the trainer and whether it is specially developed or is pre-existing equipment. The PD shall negotiate with the SE through the TST process to delete this test if appropriate.

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APPENDIX F

INTEGRATED EXPRESS PALLET PTU REQUIREMENTS

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F, INTEGRATED EXPRESS PALLET PTU REQUIREMENTS

This appendix supplies requirements that are specific to an Integrated Simulation of the EXPRESS Pallet.

F.1 EXPRESS PALLET PTU ARCHITECTURE AND INTERFACES FOR THE SSTF/PTC

Figure F-1 provides a block diagram for an Integrated EXPRESS Pallet PTU, depicting all major simulator components and interfaces between the EXPRESS Pallet PTU and the SSTF/PTC. The PTU will interface with various SSTF/PTC resources and exchange information with various SSTF core systems models, as discussed in Section F.2. Detailed requirements for simulation software and hardware components of the PTU shown in Figure F-1 are provided in Section F.3.

The PTU shall be provided as a software-only simulation hosted on a PD provided computer platform. The PTU shall not require external control or support equipment to operate (i.e., it must perform an auto-boot and start the pallet simulation model upon power-up). All attached PTSs must fit within a single DK-provided equipment rack.

F.1.1 EXPRESS PALLET EXTERNAL INTERFACES

This section provides the requirements for the physical, electrical, and data interfaces between the PTU and the SSTF/PTC resources, as well as the PTU's simulated interfaces to the ISS core systems models in the SSTF/PTC. Also addressed are the requirements for the payload's values for the Payload Resource Utilization (PRU) models in the SSTF.

F.1.2 INTERFACES TO SSTF/PTC RESOURCES

The PTU will receive support from various SSTF/PTC resources. For each SSTF/PTC resource with which the PTU interfaces, the following sections provide a description of the resource and a description of the EXPRESS Pallet PTU's specific requirements. These interfaces shall comply with the SSTF-to-PTU interface specifications given in Appendix III of the PUDG.

F.1.2.1 MIL-STD-1553B Bus

The flight-equivalent 1553 buses provide the interface to the emulated Multiplexer/ Demultiplexers (MDM), which will host actual C&DH flight software, including the Payload Executive Processor (PEP). The PTU will interface with the PEP emulator through a

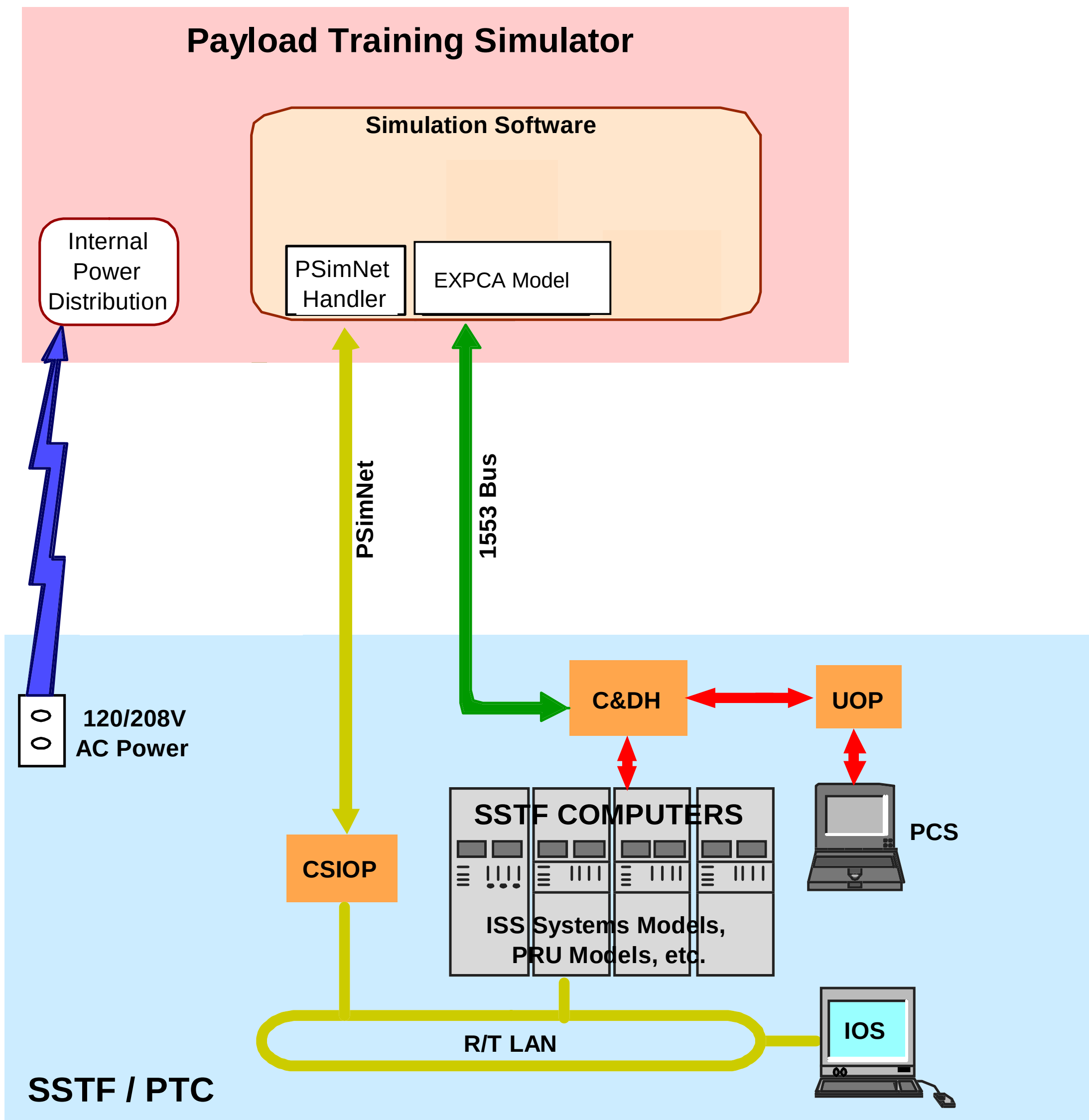

FIGURE F-1 TYPICAL INTEGRATED EXPRESS PALLET PTU

Remote Terminal (RT) interface on a payload 1553B bus. The RT address shall be determined as specified in Section 30.4.2.1 of the PUDG. The PEPs will execute ISS flight software, command and control payloads, and provide services to payloads as in flight. Note that the SSTF does not support of the High-Rate Data Link (HRDL) and has limited support for low rate telemetry, as provided in Section 30.3.3.2.1 of the PUDG. The electrical interface specifications for the 1553 bus are provided in Section 30.4.4.2.2 of the PUDG.

The PTU shall provide a flight-like implementation of the 1553 interface. All message traffic shall be simulated, except that the content of the HDRL packages need not be simulated.

F.1.2.2 Payload Simulation Network (PSimNet)

The PTU shall interface with the SSTF/PTC for simulation-unique control and data through the PSimNet Ethernet connection. This interface will provide the PTU with all of its simulation control functions, which include the commands required to initialize, control, and insert malfunctions into the PTU. The PSimNet will also provide an interface between the simulator and the SSTF core systems simulators as detailed in Section 4 of this document. The interface protocols for the PSimNet are provided in Section 30.3.3.6 of the PUDG, the logical interface specifications are provided in Section 30.4.2 of the PUDG, and the electrical interface specifications are provided in Section 30.4.4.2.1.2 of the PUDG.

The PTU shall implement the PSimNet interface to provide PTU control functions, PTU monitoring via the IOS, and SSTF core system simulator support. The PTU control functions shall include the commands required to initialize, control, and insert malfunctions into the PTU as detailed in Section 4.1 of this document. The PTU monitoring function shall provide sufficient visibility into the PTU's internal operations for an Instructor at the IOS to properly monitor those operations.

F.1.2.3 Portable Computer System (PCS)

The PCS is used to provide payload data and commanding capabilities from positions in the Lab other than the payload front panel or dedicated laptop computer. This computer is tied into the C&DH system via a 1553 interface. The PCS will be loaded with the appropriate NASA-provided flight software for each increment.

The PTU shall provide a flight-like implementation of the PCS interface, either through the 1553 or the PEHG LAN, as appropriate. All commands from the PCS and data to the PCS shall be simulated.

F.1.2.4 Electrical Power

The SSTF facility will provide electrical power and ground to the PTU location. One standard outlet will supply 120 Vac, single phase power at 8-A maximum current. The PTU shall be constructed to operate from the available SSTF power resources described above, and shall be limited to 1 kW of power dissipation.

F.2.2 INTERFACES TO CORE SYSTEMS MODELS

This section addresses the interfaces between the PTU and the ISS core systems models. These models provide simulated resource support to the payload simulators as well as serving as training tools on the ISS subsystems, and are described in Section 4.5 of the PUDG. The PTU shall be responsible for updating the data provided to the core systems models over the PSimNet, as specified below.

The Integrated EXPRESS Pallet PTU shall model the resource utilization for both the Pallet itself and its resident sub-pallet payloads, regardless of whether those payload's simulators are actually installed. The PTU's model of payload resource usage can be a simple table-driven model dependent on the power status of each payload, or it can be a more complex model taking into account the specific operational status of each payload. The PTU software shall provide data to the core systems models regardless of the power status of the payload being simulated.

The following sections provide the requirements for the interfaces between the PTU and the core systems models.

F.2.2.1 Electrical Power System (EPS) Model

The EPS model (see Section 30.3.3.1 of the PUDG) provides a power status to the PTU for both the main bus power and the essential bus power available to the Pallet. This simulation includes the emulation of the on-board utility outlet panels and a simulation of the power available to the payload. The EPS model reports the current voltage available on the main and essential buses in volts, dc. The PTU shall supply the EPS model with the real-time power load on the main and essential buses in watts. Since the real electrical power supplied to the PTU is not interactive with the power status provided by the EPS, the PTU shall make the payload appear interactive based on the power status received from EPS.

F.2.2.2 On-Board Computer System (OBCS) Model

The OBCS model consists of a combination of hardware and software components that provide a full system signature simulation of the ISS on-board C&DH system and its interface components, including the ISS PCS. The OBCS supports ISS systems command and control, supports ISS payload users, and provides services for flight crew and ground operations. The OBCS simulates the MDM which provides data processing and transfer for LSG data. Since the OBCS model runs the actual Flight Software (FSW), data processing capabilities will duplicate those available on orbit

The Pallet PTU shall support all low-rate data that is present in its 1553B flight data stream including health and status data. Low-rate health and status data that will be downlinked in flight via Ku-band is handled by a simulation-unique line that transfers low-rate payload health and status data to the MCC and subsequently to the POIC for demultiplexing and conversion to engineering units.

F.2.2.3 Communications and Tracking (C&T) Model

The C&T model uses a combination of hardware and software to simulate the services provided via S-band and Ku-Band. C&T supports all uplink and downlink capabilities of the S-band link, and the functions of the Ku-band link used to support the downlink of payload health and status and video data with the exception of HRDL capabilities. The C&T model provides Acquisition Of Signal (AOS)/Loss Of Signal (LOS) status for both S-band and Ku-band. Use of the C&T model is transparent to the Pallet PTU, therefore requiring no specific simulator interfaces.

F.2.2.4 Guidance, Navigation, and Control (GN&C) Model

The GN&C model models the flight GN&C system, providing the generation of state vectors, attitude, and pointing support data. The Pallet PTU shall not require the SSTF GN&C model.

F.2.3 PTU INTERFACE TO SUB-PALLET PAYLOADS

Provision shall be made in the EXPRESS Pallet PTU for the incorporation of software-only Sub-pallet payload models. An Integrated EXPRESS Pallet PTU shall interface with the SSTF/PTC resources for the pallet and distribute those simulated resources to any Sub-pallet payload models. For power resources, the EXPRESS Pallet PTU shall provide a power flag to simulate the flight-like control of power to Sub-pallet payloads. For data, the PTU shall provide a distribution capability to simulate the flight-like distribution of data to Sub-pallet payloads.

The Integrated EXPRESS Pallet PTU shall provide support for all PSimNet traffic that may be required to be communicated to Sub-pallet PTU models contained within the EXPRESS Pallet PTU Host computer (e.g., mode control, malfunction flags). Likewise, the integrated EXPRESS Pallet PTU shall gather health and status data from all Sub-pallet models and incorporate this data into its own PTS Data Message as described in Section 30.4.2.3.5 of the PUDG for shipment to the SSTF IOS. Station resource utilization values reported by the rack to other SSTF Station models shall be the sum of the pallet itself and all active Sub-pallet PTUs.

The PD shall provide an Integrated Pallet Simulator Interface Definition Document (IDD) that details the simulator unique pallet to sub-pallet interfaces discussed in this section. This document will be provided by the Pallet PD to those PDs that are responsible for the development of individual Sub-pallet PTUs.

F.2.4 DATA FOR PRU MODELS

For systems training when the PTU is not included in the training session configuration, the SSTF has the capability to use PRU software models to provide a minimum set of state and consumption data to simulate the load that payload would place on the ISS systems resources. PRU models are described in Section 4.9 of the PUDG, and the PRU Form that is used to collect the information needed to develop the models is provided in Section 30.5. of the PUDG. The PD shall provide the information required to generate the PRU data to MSFC by I-18 months.

F.3 PTU SOFTWARE REQUIREMENTS

The Integrated EXPRESS Pallet PTU software shall provide flight-like interfaces to the crew and ground controllers by responding to commands and providing monitoring data through the 1553 bus. The software shall accept command inputs from the SSTF executive processor via the 1553 bus and modify the payload processing parameters appropriately.

F.3.1 SIMULATION OF MALFUNCTIONS

Control for malfunctions shall be initiated at the IOS and input to the PTU software via messages through the PSimNet. The specifications for these malfunction messages are provided in Section 30.4.2.3 of the PUDG. The PTU software shall respond to the malfunction messages directed at the EXPRESS Pallet PTU itself by modifying its data processing so that the data output indicates the existence of the malfunction. The Integrated EXPRESS Pallet PTU shall maintain a table of malfunction flags for supported Sub-Pallet PTUs and shall pass these malfunction messages to the appropriate Sub-pallet PTU model. The malfunction shall be reset by a reset message from the IOS.

Malfunction requirements shall be provided to the SE by I-17 for incorporation in the PTU-specific PSRD, Volume II, as defined in Section 30.5.1 of the PUDG, so that the required messages can be generated.

F.3.2 SIMULATION OF PEP INTERFACES

This section discusses the SSTF/PTC emulation of the Payload Executive Processor (PEP) and the Payload Executive Software (PES) that provide command, control, and monitoring functions used by the PTU. The communication for these functions shall occur over the 1553 bus. Commands shall be accepted by the PEP emulation and passed on to the PTU processor for processing. Data shall be output by the PTU to the PEP for on-board monitoring and for downlink.

The PTU shall output a simulated health and status data stream through the 1553 bus. A command rate of one command per second shall be supported by the SSTF/PTC-to-PTU link. The PTU processor shall conform to standard ISS data protocol. In addition, simulated health and status data variables shall be included in PTS Data Messages sent through the PSimNet for monitoring at the IOS.

The training version of the PES, which is a duplication of the flight load, will be provided by the SSTF/PTC. After being processed by the PES, output data shall be made available on the 1553 bus for shipment to the Command and Control MDM and the PCS. If applicable, the PTU shall require the use of payload specific data files that run in conjunction with the PES. These data files allow the PTU to take advantage of the PES capabilities to display and monitor data.

Some payloads require the use of Payload Application Software (PAS) that operates in the PEP to perform additional processing on its output data parameters. The training version of this software will be provided by the SSTF/PTC, and will be a duplication of the flight load. The PTU shall provide a flight-like interface to any PAS used by the payload.

F.3.3 IOS DISPLAY REQUIREMENTS

In order to monitor internal operations of the EXPRESS Pallet PTU and supported Subpallet PTUs during a training session the simulator shall output parameters through the PSimNet to be viewed on the IOS. Note that these are parameters that may not be normally output by the real payload but are useful for keeping track of the status of the simulator. These parameters shall include sufficient information to monitor the status of any pallet hardware elements, malfunctions, and software operations. The Integrated EXPRESS Pallet PTU will incorporate IOS display information from Sub-pallet into its own PTS Data Message as described in Section 30.4.2.3.5 of the PUDG. These parameters shall be defined to the SE by I-17 for incorporation in the PTU-specific PSRD, Volume II, as detailed in Section 30.5.1 of the PUDG.

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APPENDIX G

EXPRESS SUB-PALLET PTU REQUIREMENTS

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G, EXPRESS SUB-PALLET PTU REQUIREMENTS

This appendix supplies requirements that are specific to an Integrated EXPRESS Pallet Payload experiment that will be operated on the International Space Station (ISS) if a PTU is required for training.

G.1 EXPRESS PALLET PAYLOAD PTU ARCHITECTURE AND INTERFACES FOR THE SSTF/PTC

Figure G-1 provides a block diagram for an Integrated EXPRESS Pallet Payload PTU, depicting all major simulator components and interfaces between the EXPRESS Pallet PTU and the Pallet Payload PTU. The PTU will interface with various EXPRESS Pallet resources and exchange information with EXPRESS Pallet system models, as discussed in Section G.2. Detailed requirements for simulation software and hardware components of the PTU shown in Figure G-1 are provided in Section G.3.

G.1.1 EXPRESS PALLET PAYLOAD PTU ARCHITECTURE

The Pallet Payload PTU shall be provided as a software-only simulation that interfaces to the EXPRESS Pallet PTU and is resident on the EXPRESS Pallet computer platform. The Pallet Payload PTU shall not require external control or support equipment to operate, (i.e., it must perform an auto-boot and start the pallet experiment simulation model upon power-up) all such equipment shall be contained within an equipment rack volume that contains the PTU host platform.

G.2 PTU EXTERNAL INTERFACES

This section provides the requirements for the physical, electrical, and data interfaces between a Sub-pallet PTU and the EXPRESS Pallet resources, as well as the PTU's simulated interfaces to the EXPRESS Pallet systems models.

G.2.1 INTERFACES TO PALLET RESOURCES

The EXPRESS Pallet Simulator shall support power, and data interfaces to the simulated payload locations within the Pallet PTU. For each EXPRESS Pallet resource with which the PTU interfaces, the following sections provide a description of the interface, which shall comply with the EXPRESS Pallet-to-payload simulator interface specifications given in the EXPRESS Pallet Simulator IDD as specified in Section F.2.3 of this document. Any additional resource requirements for the PTU shall be coordinated with the EXPRESS Pallet Project Office and agreed to in the TST.

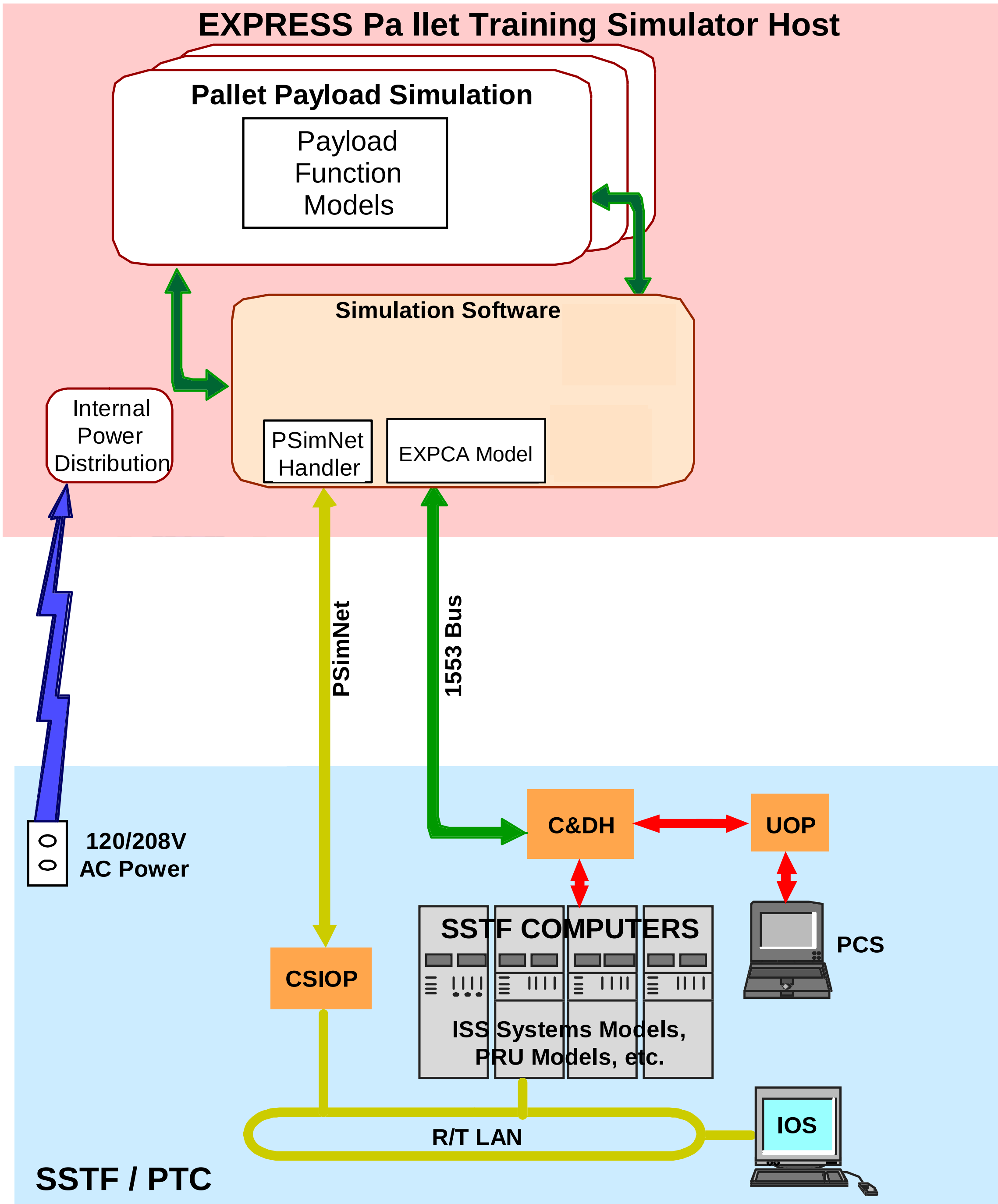

FIGURE G-1 TYPICAL SUB-PALLET PTU

G.2.1.1 EXPRESS Pallet Controller Assembly (EXPCA)) Model

The EXPCA model will manage the flow of data and information in and out of the Pallet by providing digital and analog data management services including data formatting, data multiplexing, and command distribution. The EXPCA model will provide command and control capability among the ISS C&DH subsystems, the EXPRESS Pallet payloads, and the EXPRESS Pallet subsystems. The EXPCA model shall be capable of receiving six analog inputs from each simulated sub-pallet experiment location, and shall also support six bi-directional discrete signal interfaces to each simulated sub-pallet experiment location.

The EXPRESS Pallet Simulator's EXPCA model will function to control C&DH traffic as in flight, will receive and process flight like commands, and will use the commands to update the status of software models affecting Pallet operations, payload operations, or the crew or ground displays. The EXPCA model will accept ethernet data from payloads but will then discard it. The EXPCA model will accept and pass on the Sub-pallet payload health and status data as in flight. The EXPCA model will simulate all flight-like interfaces to payloads, and the PL MDM, to properly reflect EXPRESS Pallet flight operation.

The Pallet Payload PTU shall provide the necessary flight-like interfaces to the EXPCA Model to support the crew's interfaces via the PCS, as well as to support payload command and monitoring by the GSP. The Sub-pallet PTU shall simulate the communications protocols with the Pallet EXPCA model required to support the flight-like interfaces.

G.2.1.2 Analog and Discrete Communications

The EXPRESS Pallet Simulator will simulate the analog and discrete SSPCM-to-payload interfaces in a flight-like format to support payload communication with the Pallet. The analog and discrete interfaces with Pallet Payload PTUs shall simulate the functional characteristics specified in the ISS EXPRESS Pallet Payloads IDD.

The PTU shall provide the necessary flight-like analog and discrete communications to support the crew's interfaces via the PCS, as well as to support payload command and monitoring by the GSP.

G.2.1.3 Payload Simulation Network (PSimNet)

There is only one PSimNet interface to each EXPRESS Pallet PTU in the SSTF; thus the EXPRESS Pallet Simulator will receive PSimNet commands addressed to a Pallet Payload location and distribute those commands to the appropriate PTU within the Pallet. The EXPRESS Pallet Simulator will extend the PSimNet's interface to Sub-pallet PTUs for control and monitoring. The EXPRESS Pallet Simulator will provide loading information to the SSTF/PTC via the PSimNet that reflects both Pallet and Pallet Payload consumption, regardless of the fidelity or even the presence of the payload simulators. Therefore, individual EXPRESS Pallet Payload PTUs are required to pass simulated systems loading information to the Pallet EXPCA as specified in the EXPRESS Pallet Simulator IDD.

G.2.2 INTERFACES TO SIMULATED PALLET RESOURCES

The EXPRESS Pallet Simulator will interface with the ISS core systems models via the PSimNet to receive the availability of the resources. The Pallet Simulator shall in turn provide this information to the Sub-pallet Payloads via the PSimNet Extension, as specified in the EXPRESS Pallet Simulator IDD as specified in Section F.2.2.4 of this document. The EXPRESS Pallet Simulator will provide this data regardless of the power status of the Pallet or of the Pallet Payload.

G.3 EXPRESS PALLET PAYLOAD PTU SOFTWARE

This section specifies the software capabilities required for a Sub-pallet PTU to operate within the EXPRESS Pallet PTU and the SSTF/PTC simulation environment. The PTU shall have PD-provided software that simulates all major aspects of the flight payload processor and also provides simulation-unique functions. The PTU software shall reside in the EXPRESS Pallet PTU Payload Simulator Environment (PSE), and shall provide a flight-like representation of the operations and interfaces of the payload. The software shall provide flight-like interfaces to the crew and ground controllers by responding to commands and providing monitoring data through a simulated 1553 bus interface.

The Pallet Payload PTU software shall interface with the EXPRESS Pallet Simulator and with the SSTF/PTC through an extension of the PSimNet to perform initialization, mode control, and malfunction insertion. The interface specifications for the EXPRESS Pallet PSimNet extension are provided in EXPRESS Pallet Simulator IDD as specified in Section 4.3 of this document.

G.3.1 SIMULATION OF NOMINAL OPERATIONS

The EXPRESS Sub-pallet PTU software shall provide simulation of the nominal operations of the payload that involve crew interactions through software displays. Operations that shall be simulated include, but are not limited to, activation/deactivation, calibration, science gathering, and data. The PTU shall also support control and monitoring of the payloads operations from the ground. The PTU software shall respond to changes in EXPRESS Pallet resources by exhibiting the appropriate response in the payload’s status.

G.3.2 SIMULATION OF MALFUNCTIONS

Malfunction requirements shall be provided to the EXPRESS Pallet Simulator integrator (SE) as defined in EXPRESS Pallet Simulator IDD as specified in Section F.2.2.4 of this document.

G.3.3 SIMULATION OF EXPCA INTERFACES

This section discusses the EXPRESS Pallet Simulator modeling of the EXPCA that provides command, control, and monitoring functions used by the Pallet Payload PTU. Commands will be accepted by the EXPCA model and passed on to the Pallet Payload PTU for processing. Data shall be output by the Pallet Payload PTU to the EXPCA model for on-board monitoring and for downlink.

The Pallet Payload PTU shall interface as appropriate to simulate flight operations with the Pallet EXPCA model. The Pallet EXPCA software will work in conjunction with payload-specific data files to perform processing on the output data parameters and allow the transfer of commands for uplink/PCS commanding. After being processed by the EXPCA model, data will be made available to the 1553 bus for shipment to the Command and Control MDM emulation in the SSTF/PTC. The Pallet PTU will also use payload-specific data files in the Pallet EXPCA model to allow the Pallet Payload PTU to take advantage of the EXPRESS Pallet Simulator’s capabilities to display and monitor data on the PCS.

The Pallet Payload PTU shall output a simulated health and status data stream to the Pallet EXPCA model. In addition, simulated health and status data variables shall be included in PTS data messages sent through the PSimNet for monitoring at the IOS.

G.3.4 IOS DISPLAY REQUIREMENTS

In order to monitor internal operations of a Sub-Pallet PTU during a training session, the PTU shall output parameters through the PSimNet extension to be viewed on the IOS. Note that these parameters may not be normally output by the real payload but are useful for keeping track of the status of the PTU. These parameter shall include sufficient information to monitor the status of any hardware elements, malfunctions, and software operations. These parameters shall be defined to the EXPRESS Pallet SE as defined in EXPRESS Pallet Simulator IDD as specified in Section F.2.3 of this document.

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APPENDIX H

ATTACHED PAYLOAD PTU REQUIREMENTS

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H, ATTACHED PAYLOAD PTU REQUIREMENTS

This appendix supplies requirements that are specific to an Integrated Attached Payload that will be operated on the International Space Station (ISS) if a PTU is required for training.

H.1 ATTACHED PAYLOAD PTU ARCHITECTURE AND INTERFACES FOR THE SSTF/PTC

Figure H-1 provides a block diagram for an Integrated Attached Payload PTU, depicting all major simulator components and interfaces between the Attached Payload PTU and the SSTF/PTC. The PTU will interface with various SSTF/PTC resources and exchange information with various SSTF core systems models, as discussed in Section H.2. Detailed requirements for simulation software and hardware components of the PTU shown in Figure H-1 are provided in Section H.3.

H.1.1 ATTACHED PAYLOAD PTU ARCHITECTURE

The PTU shall be provided as a software-only simulation hosted on a PD-provided computer platform. The PTU shall not require external control or support equipment to operate (i.e., it must perform an auto-boot and start the Attached Payload simulation model upon power-up). All attached PTSs must fit within a single DK-provided equipment rack.

H.1.2 ATTACHED PAYLOAD EXTERNAL INTERFACES

This section provides the requirements for the physical, electrical, and data interfaces between the PTU and the SSTF/PTC resources, as well as the PTU’s simulated interfaces to the ISS core systems models in the SSTF/PTC. Also addressed are the requirements for the payload’s values for the Payload Resource Utilization (PRU) models in the SSTF.

H.1.2.1 Interfaces to SSTF/PTC Resources

The PTU will receive support from various SSTF/PTC resources. For each SSTF/PTC resource with which the PTU interfaces, the following sections provide a description of the resource and a description of the Attached Payload PTU’s specific requirements. These interfaces shall comply with the SSTF-to-PTU interface specifications given in Appendix III of the PUDG.

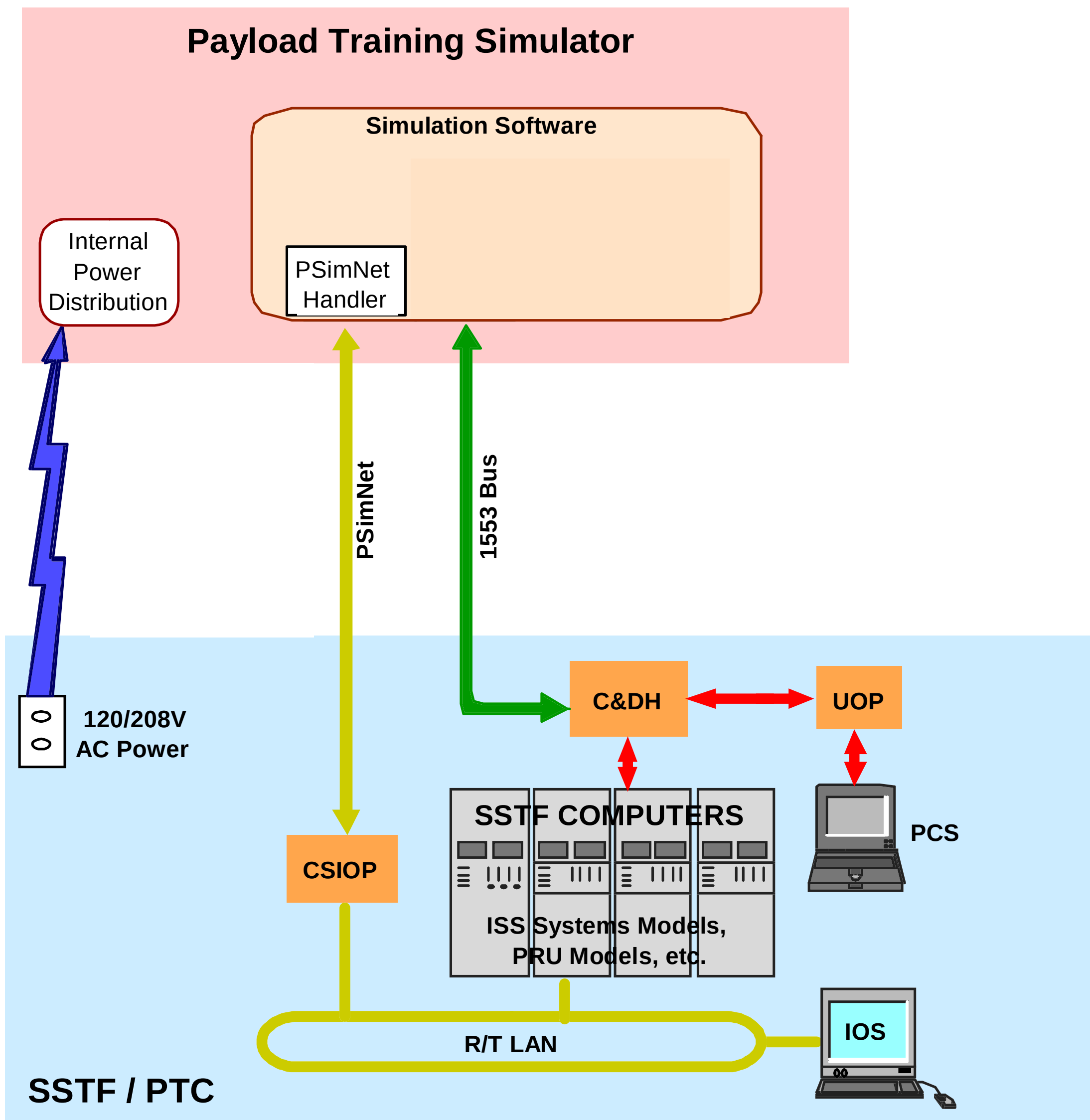

FIGURE H-1 INTEGRATED ATTACHED PAYLOAD PTU

H.1.2.1.1 MIL-STD-1553B Bus

The flight-equivalent 1553 buses provide the interface to the emulated Multiplexer/ Demultiplexers (MDM), which will host actual C&DH flight software, including the Payload Executive Processor (PEP). The PTU will interface with the PEP emulator through a Remote Terminal (RT) interface on a payload 1553B bus. The RT address shall be determined as specified in Section 30.4.2.1 of the PUDG. The PEPs will execute ISS flight software, command and control payloads, and provide services to payloads as in flight. Note that the SSTF has limitations to its support of the High-Rate Data Link (HRDL) and low rate telemetry, as provided in Section 30.3.3.2.1 of the PUDG. The electrical interface specifications for the 1553 bus are provided in Section 30.4.4.2.3 of the PUDG.

The PTU shall provide a flight-like implementation of the 1553 interface. All message traffic shall be simulated, except that the content of the HDRL packages need not be simulated.

H.1.2.1.2 Payload Simulation Network (PSimNet)

The PTU shall interface with the SSTF/PTC for simulation-unique control and data through the PSimNet Ethernet connection. This interface will provide the PTU with all of its simulation control functions, which include the commands required to initialize, control, and insert malfunctions into the PTU. The PSimNet will also provide an interface between the simulator and the SSTF core systems simulators as detailed in Section 4of this document. The interface protocols for the PSimNet are provided in Section 30.3.3.6 of the PUDG, the logical interface specifications are provided in Section 30.4.2 of the PUDG, and the electrical interface specifications are provided in Section 30.4.4.2.2.2 of the PUDG.

The PTU shall implement the PSimNet interface to provide PTU control functions, PTU monitoring via the IOS, and SSTF core system simulator support. The PTU control functions shall include the commands required to initialize, control, and insert malfunctions into the PTU as detailed in Section 4.1 of this document. The PTU monitoring function shall provide sufficient visibility into the PTU’s internal operations for an Instructor at the IOS to properly monitor those operations.

H.1.2.1.3 Portable Computer System (PCS)

The PCS is used to provide payload data and commanding capabilities from positions in the Lab other than the payload front panel or dedicated laptop computer. This computer is tied into the C&DH system via a 1553 interface. The PCS will be loaded with the appropriate NASA-provided flight software for each increment.

The PTU shall provide a flight-like implementation of the PCS interface, either through the 1553 or the PEHG LAN, as appropriate. All commands from the PCS and data to the PCS shall be simulated.

H.1.2.1.4 Electrical Power

The SSTF facility will provide electrical power and ground to the PTU location. One standard outlet will supply 120-Vac, single phase power at 12 A. The PTU shall be constructed to operate from the available SSTF power resources described above, and shall be limited to 1 kW of power dissipation.

H.1.2.2 Interfaces to Core Systems Models

This section addresses the interfaces between the PTU and the ISS core systems models. These models provide simulated resource support to the payload simulators as well as serving as training tools on the ISS subsystems, and are described in Section 4.5 of the PUDG. The PTU shall be responsible for updating the data provided to the core systems models over the PSimNet, as specified below.

The Integrated Attached Payload PTU shall simulate the resource utilization for both the Attached Payload itself and any associated sub-payloads, regardless of whether those payload's simulators are actually installed. The PTU's model of payload resource usage can be a simple table-driven model dependent on the power status of each payload, or it can be a more complex model taking into account the specific operational status of each payload. The PTU software shall provide data to the core systems models regardless of the power status of the payload being simulated.

The following sections provide the requirements for the interfaces between the PTU and the core systems models.

H.1.2.2.1 Electrical Power System (EPS) Model

The EPS model (see Section 30.3.3.1of the PUDG) provides a power status to the PTU for both the main bus power and the essential bus power available to the Attached Payload. This simulation includes the emulation of the on-board utility outlet panels and a simulation of the power available to the payload. The EPS model reports the current voltage available on the main and essential buses in volts, dc. The PTU shall supply the EPS model with the real-time power load on the main and essential buses in watts. Since the real electrical power supplied to the PTU is not interactive with the power status provided by the EPS, the PTU shall make the payload appear interactive based on the power status received from EPS.

H.1.2.2.2 On-Board Computer System (OBCS) Model

The OBCS model consists of a combination of hardware and software components that provide a full system signature simulation of the ISS on-board C&DH system and its interface components, including the ISS PCS. The OBCS supports ISS systems command and control, supports ISS payload users, and provides services for flight crew and ground operations. The OBCS simulates the MDM which provides data processing and transfer for LSG data. Since the OBCS model runs the actual Flight Software (FSW), data processing capabilities will duplicate those available on orbit. The SSTF OBCS simulates the HRDL, but does not support the TAXI for payload-to-payload communications or payload downlink through Ku-band.

The Attached Payload PTU shall support all low-rate data that is present in its 1553B flight data stream including health and status data. Low-rate health and status data that will be downlinked in flight via Ku-band is handled by a simulation-unique line that transfers low-rate payload health and status data to the MCC and subsequently to the POIC for decommutation.

H.1.2.2.3 Communications and Tracking (C&T) Model

The C&T model uses a combination of hardware and software to simulate the services provided via S-band and Ku-Band. C&T supports all uplink and downlink capabilities of the S-band link, and the functions of the Ku-band link used to support the downlink of payload health and status and video data with the exception of HRDL capabilities. The C&T model provides Acquisition Of Signal (AOS)/Loss Of Signal (LOS) status for both S-band and Ku-band. Use of the C&T model is transparent to the Attached Payload PTU, therefore requiring no specific simulator interfaces.

H.1.2.2.4 Guidance, Navigation, and Control (GN&C) Model

The GN&C model models the flight GN&C system, providing the generation of state vectors, attitude, and pointing support data. The Attached Payload PTU shall not require the SSTF GN&C model.

H.1.2.3 Data for PRU Models

For systems training when the PTU is not included in the training session configuration, the SSTF has the capability to use Payload Resource Utilization (PRU) software models to provide a minimum set of state and consumption data to simulate the load that payload would place on the ISS systems resources. PRU models are described in Section 4.9 of the PUDG, and the PRU Form that is used to collect the information needed to develop the models is provided in Section 30.5 of the PUDG. The PD shall provide the information required to generate the PRU data to MSFC by I-18 months.

H.1.3 PTU SOFTWARE REQUIREMENTS

The Integrated Attached Payload PTU software shall provide flight-like interfaces to the crew and ground controllers by responding to commands and providing monitoring data through the 1553 bus. The software shall accept command inputs from the SSTF executive processor via the 1553 bus and modify the payload processing parameters appropriately.

H.1.3.1 Simulation of Malfunctions

Control for malfunctions shall be initiated at the IOS and input to the PTU software via messages through the PSimNet. The specifications for these malfunction messages are provided in Section 30.4.2.3.6 of the PUDG. The PTU software shall respond to the malfunction messages directed at the Attached Payload PTU itself by modifying its data processing so that the data output indicates the existence of the malfunction. The malfunction shall be reset by a reset message from the IOS.

Malfunction requirements shall be provided to the SE by I-17 for incorporation in the PTU-specific PSRD, Volume II, as defined in Section 30.5.1 of the PUDG, so that the required messages can be generated.

H.1.3.2 Simulation of PEP Interfaces

This section discusses the SSTF/PTC emulation of the Payload Executive Processor (PEP) and the Payload Executive Software (PES) that provide command, control, and monitoring functions used by the PTU. The communication for these functions shall occur over the 1553 bus. Commands shall be accepted by the PEP emulation and passed on to the PTU processor for processing. Data shall be output by the PTU to the PEP for on-board monitoring and for downlink.

The PTU shall output a simulated health and status data stream through the 1553 Bus. A command rate of one command per second shall be supported by the SSTF/PTC-to-PTU link. The PTU processor shall conform to standard ISS data protocol. In addition, simulated health and status data variables shall be included in PTS data messages sent through the PSimNet for monitoring at the IOS.

The training version of the PES, which is a duplication of the flight load, will be provided by the SSTF/PTC. After being processed by the PES, output data shall be made available on the 1553 bus for shipment to the Command and Control MDM and the PCS. If applicable, the PTU shall require the use of payload-specific data files that run in conjunction with the PES. These data files allow the PTU to take advantage of the PES capabilities to display and monitor data.

Some payloads require the use of Payload Application Software (PAS) that operates in the PEP to perform additional processing on its output data parameters. The training version of this software will be provided by the SSTF/PTC, and will be a duplication of the flight load. The PTU shall provide a flight-like interface to any PAS used by the payload.

H.1.3.3 IOS Display Requirements

In order to monitor internal operations of the Attached Payload PTU during a training session, the simulator shall output parameters through the PSimNet to be viewed on the IOS. Note that these are parameters that may not be normally output by the real payload but are useful for keeping track of the status of the simulator. These parameters shall include sufficient information to monitor the status of any Attached Payload hardware elements, malfunctions, and software operations. These parameters shall be defined to the SE by I-17 for incorporation in the PTU-specific PSRD, Volume II, as detailed in Section 30.5.1 of the PUDG.

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